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THE MONTE VIDEO HARBOR WORKS, which were referred to in our last issue, are described in more detail in the "South American Journal" of July 29. From this we learn that plans for the work were prepared during the Borda government some years ago by Mr. Guerard, and have been generally accepted as a sound and well considered engineering scheme. Financial difficulties have hitherto prevented the carrying out of these plans, but the government now proposes to impose an additional import duty of 2½% and an export duty of 1%, yielding an annual revenue estimated at $850,000 per annum. The total cost of the works is estimated at $11,590,000, and the time for completion is set at eight years. The above revenue will provide for $6,800,000 of this, and sale of reclaimed lands, cash now available, and other items, bring the total up to $8,622,000. To raise the balance of this sum it is proposed to issue bonds of the port for $5,500,000, to bear interest at 6%, which it is estimated can be sold at 73%, yielding in cash 4,015,000.

A VENEZUELA CONCESSION for the coal mines, railways and wharves at Guanta, State of Bermudez, has been granted to Lanzoni, Martini & Co., of Rome, Italy, The contract is to run for 15 years on the payment of $20,012 gold annually by the company and 9.6 cts. gold per ton for all coal extracted. The company must not charge the government more than the present price of $4.82 gold per ton for coal, and the railway rates are to remain as at present. Work on the mines and railways is to commence in four months from June 23, 1899, and all new work is to be finished in eight months.

THE SYRIA-OTTOMAN RY. is being promoted by Mr. J. R. Pilling, Effingham House, Arundel St., London, and Mr. H. Hills, of the Thames Iron Works, London. The proposed capital is $5,000,000, but no shares will be put on the market, so it is said, until the line is completed as far as Nazareth. The road will run from Haifa, a seaport 75 miles south of Beirut, to Damascus, a distance of some 142 miles, and the project includes an extension from Damascus to Bagdad and the Persian Gulf. While the Jaffa & Jerusalem Ry. (54 miles), the Beirut, Damascus & Hauran Ry. (153 miles), and the Lebanon Tramway (10 miles) are narrow gage, the Haifa & Damascus line, or Syrian-Ottoman Ry. will be of standard gage. It is primarily intended to tap the great Hauran wheat regions, and to afford another outlet for the growing trade of Damascus. Active operations were commenced last spring on the division between Haifa and the Jordan, and the line is to be completed in less than two years as far as Damascus. Sir Douglas Fox (28 Victoria St., London) is the chief engineer, while Dr. G. Schumacher (civil engineer and U. S. consular agent) is superintendent of works at Haifa, assisted by Mr. H. T. Foord, agent of the company. The Thames Iron Works being crowded with orders, it is possible that rails, locomotives, and other material will be bought in the United States, according to a statement made by the U. S. consul at Beirut.

THE FOREIGN TRADE STATISTICS OF THE UNITED States of the last decade show a gradual reversal of the relative position occupied by the exports and imports of manufactured goods, says "Bradstreet's." In 1890 the imports of manufactures exceeded the exports by over $205,500,000; in 1899, the excess on the other side was over $79,000,000. In the fiscal year 1897 the imports were over $97,000,000 less than in 1890, with exports greater by $187,500,000. In 1880 the export of manufactures was only 12.48% of the total volume of exported goods; in 1889 it was 18.99%, and by 1894 it was 21.14% of the total. For the last fiscal year manufactures constituted 28.13% of the total, and for some months, one-third of the total.

A DOCKYARD AT CAVITE, in the Philippine Islands, is recommended by Lieut. R. P. Hobson in a late report to the Navy Department. At present all U. S. warships must be docked at Hong Kong, with consequent disadvantage and cost. He also reports on the three Spanish vessels raised in Manila Bay and refitted at Hong Kong. The total estimated value of these ships is $610,000, while the cost to the government of raising and refitting them will be about $304,000. The repairs are about 80% completed, but the batteries and electric plant had not arrived at Hong Kong on July 17.

ENGLISH SHIPBUILDERS, so far this year, have launched 368 vessels, aggregating 802,344 tons gross; as compared with 418 vessels, of 785,527 tons gross in the first seven months of 1898, and 402 vessels, of 613,256 tons gross, in the same period in 1897.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on Aug. 9, at St. Polycarpe, Que., on the Canada Atlantic R. R. The engine of the Ottawa express left the rails, taking with it the baggage car and the second-class coach, which were completely wrecked. Seven people were killed and six were injured. The rails seemed to be in perfect condition, and the cause of the accident has not yet been determined.

A HURRICANE OF UNUSUAL VIOLENCE devastated many of the West India islands during the past week. Porto Rico has been the chief sufferer, and it is estimated that 100,000 people are homeless in that island alone, while the lives lost may be numbered by thousands.

STREET-CAR ACCIDENTS IN NEW YORK show an increase over former years, as one result of increased speed in surface traffic. The records of the Health Board show that in the first six months of this year, 48 persons were killed in surface-car accidents in Greater New York. In this same period the New York Central, New York, New Haven & Hartford, Long Island, and the Harlem railways killed only 28 persons.

THE ACETYLENE GAS PLANT of the Wabash Valley Gas Co., at Wabash, Ind., was destroyed by an explosion on Aug. 7. The details of the accident are not yet at hand. This was the first plant ever erected for the manufacture of acetylene gas for general town distribution.

FOUR FIREMEN WERE KILLED at Omaha, Neb., Aug. 9, as the result of allowing the ladder of an extension truck to come in contact with an electric light wire carrying 2,000 volts.

POISONING FROM LEAD WATER SERVICE PIPES at Milford and Hopedale, Mass., is reported as a dangerous possibility and the Milford Water Co. has been requested to replace the lead pipes with some other material.

THE SEWAGE DISPOSAL PLANT which is to be built at Marion, Ia., will have "head-end" cinders from locomotive smokeboxes as the filtering material, no suitable sand being available. The cinders are of very uniform size, and they have the advantage of being porous. The efficiency of this material has enabled the size of the beds to be reduced to one-third of the size originally planned for sand filtration. The septic tank will have concrete walls and bottom, brick piers and brick and concrete roof arches. Messrs. Wardle & Yeager, of Cedar Rapids, Ia., are the engineers, and Messrs. Snow & Barbour, of Boston, Mass., are consulting engineers for the disposal plant.

OVER-IRRIGATION, says the U. S. Department of Agriculture, results in excessive alkali in certain soils in California and Utah. The water applied to the soil seems to bring the salts to the surface when it rises, and in some instances the lower portions of streams have been rendered alkaline by the return of these salts from the irrigated fields. Experiments are now being made to find the least quantity of water that can be used under these conditions, and for given crops in given localities. One advantage of such demonstration is that more land can be watered from a given source with greater economy in the use of water.

TO STOP RIVER EROSION on the Missouri River, Hon. A. L. Van Osdel, of Yankton Co., S. D., is experimenting with bundles of willow twigs, says the "Globe-Democrat," of St. Louis. He places three bundles of willows, each about 6 ft. long, one above the other, in groups from 30 to 75 ft. apart along the bank, and weights each down with stone, the bundles being also fastened to a stake. He has thus protected about one mile of river bank at a cost of $150, and says that while the river cuts into the bank above his work, the bundles, so far, protect the mile treated. The soil is sandy.

A WATERWAY OR CANAL to connect the Illinois River with Lake Michigan is now being surveyed under the direction of Major Marshall, U. S. Engineers. As the Chicago River is too narrow and crowded for additional traffic the proposed route will start from some point near the Calumet River and strike the Drainage Canal near Sag Bridge, while another cut will connect this canal with the basin of the Illinois & Michigan Canal at Lockport. The canal will be improved and enlarged as far as Lake Joliet, beyond which the route will follow the Des Plaines River and the Illinois River to the Mississippi. This proposed waterway is to be 160 ft. wide and 8 to 10 ft. deep.

THE PORT ARTHUR SHIP CANAL, says its superintendent, Mr. John C. Collins, has its whole channel dredged to 19½ ft., and 4 miles dredged to 20½ ft. deep. Two wharves, 1,500 ft. long, have been built; a warehouse, 100 by 700 ft., is building; a 500,000-bushel grain elevator is in operation; and a contract is let for a lumber wharf, 1,750 ft. long. He expects that ships can be loaded by Sept. 15 next. About 18 miles of yard track are being laid.

CHEAPER RAILWAY FARES are now a conspicuous feature in Russian railway policy, says "Engineering." There are now open to traffic in that empire 26,750 miles of railway, and no less than 7,400 miles are either under construction or decided upon, about one-half of the latter being state railways. In 1886 the total number of passengers carried amounted to 37,885,000, and this figure had risen to 655,000,000 in 1896, owing to the introduction of the zone system of fares. Under this tariff the third-class fare for 150 versts, or 100 miles, is nearly ½ ct. per mile; between 100 and 200 miles, it is ⅓ ct. per mile, and from 200 miles upward the rate is per zone, according to a sliding scale applying both to fare and length of zone. After 200 miles the first eight zones are 16.7 miles each, or 25 versts; the next seven are 23 miles wide each; above 997 miles the zones remain at 33 miles each and the fare is barely 10 cts. per zone. Second-class fare costs about half as much again, and first-class is twice as much as third-class fare. While these fares are extremely low, especially for long distances, a further reduction is under consideration.

A NOVEL LOCOMOTIVE VALVE GEAR is described in the "Revue Generale des Chemins de Fer," of April, 1899. The gear is in use on locomotives of the Compagnie du Chemin der Fer du Nord de L'Espagne. An ordinary three-ported slide valve is operated by a Stephenson link, and on the top of this slides a riding or expansion valve, which is operated by a stem attached permanently to that part of the link corresponding to the forward motion. By means of this device as early a cut-off as desired can be obtained without changing the amount of compression, thus securing a better indicator card when operating at high speeds. The description in the above journal is accompanied by numerous views and diagrams, including a two-page inset showing the complete mechanism; but no results are given as to the effects of the device on either the fuel economy or the power of the locomotive.

THE IMPROVEMENT OF CUBAN HIGHWAYS is contemplated by the War Department, and orders will be issued to Gen. Brooks to secure reports at once from the several department commanders in Cuba as to the present condition of the roads and an estimate of the cost of improving them. It is believed that work on road improvement will furnish employment for many Cubans and largely reduce if not entirely stop the necessity for a free distribution of food. Bad roads are now seriously handicapping many sections where work has been resumed on the old plantations. A general plan for this road improvement will be later outlined under Assistant Secretary of War Meiklejohn and submitted to the President for approval.

THE PROPOSED GUAYAQUIL & QUITO RAILWAY IN ECUADOR.

One of the most important railway schemes now under way in South America is the proposed extension of the Ferrocarril del Sur, of Ecuador, east and north from its present terminus at Puente de Chimbo to the city of Quito, a distance of about 231 miles. The Ecuador Development Co., of New York city, has the concession for this work, which is in charge of Mr. Wm. F. Shunk as Chief Engineer, and Mr. W. D. Buckner as Assistant Chief Engineer. We are indebted to Mr. Buckner, who has recently been in this country on business connected with the work, for the information from which the following description of some of its principal features has been prepared.

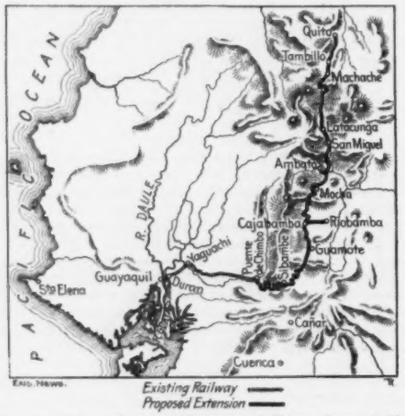

Fig. 1.—Map Showing Proposed Extension of the Ferrocarril del Sur of Ecuador from Chimbo to Quito.

Wm. F. Shunk, Chief Engineer; W. D. Buckner, Assistant Chief Engineer.

Ecuador Development Co., New York, N. Y., Builders.

The Ferrocarril del Sur is the only railway in actual operation in Ecuador. It runs from the town of Duran, which has ferry connection with Guayaquil, just across the river Guyamas, to the town of Chimbo, a distance of between 80 and 90 kilos., or over 55 miles. There is only a moderate percentage of curvature on the line, nearly 12 kilos. of tangent across the swamps being encountered soon after leaving Duran, after which the line follows the rivers Chimbo and Milagro very closely for a distance of over 50 kilos., there being encountered in the whole length of the line seven towns of considerable size, with sugar factories of about 50 tons capacity each, at the towns of Naranjito and Milagro, which have, respectively, about 1,200 and 2,200 inhabitants. The equipment of the road, which is narrow gage, consists at present of four locomotives and 36 cars, to which it is proposed to add at once three locomotives and about 150 cars. It is also proposed to establish shops, with a saw mill and woodworking machinery in connection, and to replace the present wooden docks at Guayaquil with a steel wharf, as well as to provide a ferry-boat of sufficient size to transfer the cars across from Duran.

The distance from Chimbo to Quito, by the proposed extension, will be about 230 miles, with a branch 10 miles long to Riobamba, and one 2 miles long to Ambato. The freight between Quito and Guayaquil is now carried by about 70,000 mules and donkeys, at a cost of about eight sucres per 100 lbs., on highways, which are in many places of splendid construction, and which, together with existing stone bridges, are to be used where desired, for the location of the new railway. The amount of traffic in 1891, the date of the latest reliable record, was over 210,000 passengers; freight from the interior, consisting of cereals, vegetables, hides, leather and general products, about 14,600,000 lbs., and freight to the interior, consisting mainly of imported goods, salt and sugar, nearly 30,000,000 lbs.

The surveys for the lines have been made, using 4% maximum grades and 20° maximum curves. The work through the mountains will be mainly side hill cutting, but as the gage is 1 m. (3.28 ft.) the work will not be heavy. Over some portions of the distance very careful comparative surveys have been made to determine the shortest and most economical location. One of these, between Chimbo and Cajabamba, shows the distance via Sibambe to be 95.5 miles, with over 50% of 3% and 4% grades, while by the Nava Cruz route the distance is only 79.5 miles, but there is 88% of 3% and 4% grades.

The rise in elevation between Chimbo and Sibambe is over 8,000 ft. in the 65 miles of distance. The country is entirely mountainous and densely timbered with valuable species of hard woods, but there are no settlements of any consequence. From Sibambe, at an elevation of 9,040 ft. above sea level, the road runs through the center of the great plateau of Central Ecuador to Quito, which has an elevation of 9,350 ft. The lowest point in this section is at Ambato, elevation 8,304 ft., while the highest is at Mocha, elevation 10,810 ft. The large towns are Guamote, with 12,000 inhabitants; Cajabamba, with 15,000; Riobamba, with 60,000; Ambato, with 30,000; Lacunga, with 25,000; and Machache, with 10,000.

The plateau is 60 miles wide and 170 miles long, with an average elevation of about 9,500 ft., and is surrounded by more than twenty snow-capped peaks. The snows feed the mountain streams so that there is an abundance of water available all the year round, and at convenient distances to supply power for the electrical operation of the road, which is proposed for some future time. There are, however, undeveloped coal fields of considerable extent and richness, on the line of the road about 200 miles from Guayaquil, at which place Australian coal sells at from $10 to $18 per ton. At Quito there is no fuel, and wood or charcoal is brought in on mule-back. Large quantities of oil are to be found in the province of Guayas, north of Guayaquil, and there is evidence of large quantities along the road. There are deposits of iron ore and limestone at Tambillo, and in the province of Chimborazo are found copper, ochre, sulphur, and some silver and gold. In the vicinity of Latacunga are quarries of pumice stone, which makes a very light and handsome building material.

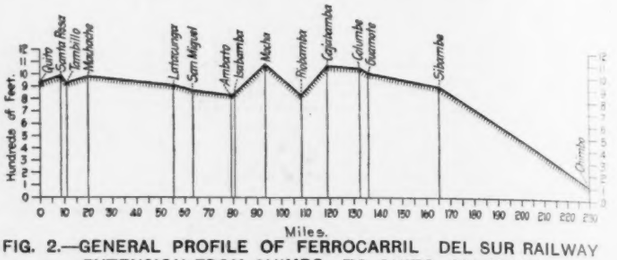

FIG. 2.—GENERAL PROFILE OF FERROCARRIL DEL SUR RAILWAY EXTENSION FROM CHIMBO TO QUITO, 231 MILES.

The freight to be carried by the road, in addition to the materials which have been mentioned, will consist of the imported goods for the interior and the natural exchange of commodities between the temperate and tropical zones. Hay has no market value in Quito, but with no railway hay is imported for Guayaquil and is worth about $25 per ton in gold. Very much the same conditions are true of potatoes, wheat, flour, corn, hides and the like.

The products of the plateau consist of cereals, fruits, vegetables, live stock, hides, cotton, and pretty nearly everything else common to temperate zone countries. The products are raised by irrigation, which is carried on extensively with well-developed irrigation systems. There are factories for the manufacture of light cotton goods and straw hats, besides flour mills, breweries, distilleries and tanneries. In the country between Chimbo and Duran, which is semitropical, the products are cocoa, sugar, rice, coffee, cotton, tobacco, and all tropical fruits and vegetables. The annual production of cocoa is about 20,000 tons, of sugar about 6,000 tons, and of coffee about 40,000 quintals.

The concession for the new road which, as has been already stated, is held by the Ecuador Development Co., of New York city, provides for the use free of cost of the highways and bridges of the 65 miles of national road from Quito to Guayamote; for free right of way elsewhere; for

FIG. 3.—VIEW OF GUAPULO AND THE VALLEY OF PUEMBO.

FIG. 4.—VIEW OF QUITO FROM THE PICHINCHA HILL SHOWING SURROUNDING COUNTRY.

such government land in the various towns passed through, as is needed for railway purposes; for dock property at Guayaquil, and for many other valuable properties and rights. The construction will involve some very interesting engineering problems, in the building of the wharf; the repair of the line to Chimbo; and the construction of the mountain section, which will present problems almost identical with those which have been solved in building the Rocky Mountain roads of North America. The construction of the plateau section will present no work of unusual interest.

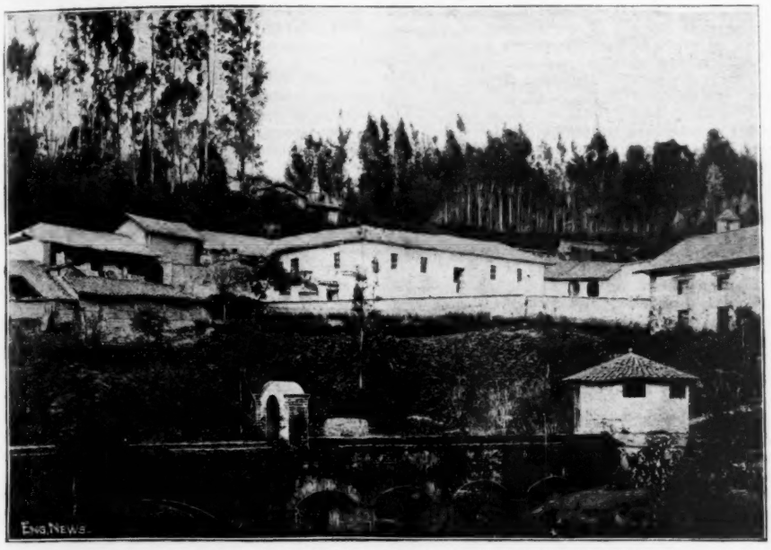

FIG. 5.—THE "VICTORIA" CLOTH FACTORY AND MILLS AT QUITO.

The illustrations which are presented in Figs. 1 to 6, inclusive, give a very good idea of the natural features of the country through which the proposed new railway will pass, and show the types of buildings which are met with in the larger towns. Among the latter the "Victoria" textile mills, and the famous astronomical observatory at Quito will be of especial interest to Americans. The contrast between the former establishment and the buildings of an up-to-date New England cotton cloth mill is a commentary in itself upon the different industrial conditions prevailing in the two countries. In respect to the profile shown in Fig. 2, it should be stated that it has been constructed with no further data than the known elevations of the larger towns along the route, and should be studied with this understanding.

THE WORK OF THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.*

Prior to the year 1800 little was known of the properties of the materials of construction. Galileo had shown in 1638 that the strength of a rectangular beam varied with the square of its depth, Hooke in 1678 had announced the law that the stretch of a spring was proportional to the stress upon it, various authors had discussed the forms of beams of uniform strength, and Euler in 1744 had enunciated his formula for the resistance of columns under compression. Theory was far in advance of practice, for experiments had been so few and so imperfect that the elastic limit was scarcely recognized.

During the years from 1800 to 1850 great progress was made in the theory of elasticity, and a slow growth took place in knowledge of the properties of materials under stress. The introduction of railways and the consequent necessity of providing a firm roadbed and safe bridge structures gave a powerful stimulus to the investigation of metals in order that ample security might be afforded with the greatest degree of economy. The methods of testing were, however, so imperfect that progress was slow, and, with the exception of the classic researches of Hodgskinson, the work of this period was mostly of value as a preparation for that of the future.

After 1850 large testing machines for special purposes began to be built, elongation and ductility began to be carefully studied, and soon after 1870 it was recognized by many manufacturers that physical tests of metals were imperatively necessary in order to secure uniformity of product. As these tests were multiplied and the records subjected to investigation, the knowledge was gained that the strength of a specimen depended upon its size and proportions and also upon the manner in which the load was applied. The term elastic limit assumed a new significance when it became recognized that it could be defined and measured in different ways. In short, it was found that tests of materials must be made in a similar manner in order to render the results comparable. This idea, although long recognized, has proved a difficult one to realize. It has been discussed by many engineering societies, some of which have attempted to formulate standard methods. Finally the International Association for Testing Materials was formed in order to study the whole subject and endeavor to arrive at conclusions that should be authoritative.

In 1882, through the influence of John Bauschinger, a number of German experimentors met at Munich and discussed the question as to how uniformity in the methods of testing materials could be promoted. As a result of this meeting formal conferences were held at Dresden in 1884, at Berlin in 1886, at Munich in 1888 and at Vienna in 1893, and at many of these delegates from other European countries were present. The reports of the proceedings of these conferences, published in Bauschinger's "Mitthellungen," attracted wide attention, and the great value and importance of the discussions became universally recognized in engineering circles. In short, the movement assumed an international character.

In 1890, as a result of the international congresses of engineering held at Paris in the preceding year, the French government appointed a commission to formulate standard methods for testing the materials of construction. Its report, published in 1894 in four large volumes, is one of the most valuable contributions to the subject, but from the first it was recognized that ultimate conclusions could not be determined by a commission of one nationality, and accordingly, since 1895, the French government has given hearty support to the work of the International Association.

In 1895, as a result of the four preceding conferences, the fifth conference met at Zurich, all European countries, except Turkey, being represented. The United States government was represented by an army officer and the American Society of Mechanical Engineers by a delegate. At this congress the International Association for Testing Materials was formally organized, its object being, as stated in its statutes, "the development and unification of standard methods of testing for the determination of the properties of the materials of construction and of other materials, and also the perfection of apparatus for that purpose." This meeting at Zurich hence assumed an importance far greater than any preceding conference, and it may be called the first congress of the International Association.

At the Vienna convention of 1893 there had been appointed 20 committees on technical subjects, and reports from many of these were presented at the Zurich congress of 1895. These reports were published in the French and German languages in the official organ of the Association called "Baumaterialienkunde," the first number of which appeared in July, 1896. The work of some of these committees was continued, other subjects were proposed for future consideration, and a council was organized to transact the business of the International Association in the intervals between the congresses.

In 1897 the second congress of the International Association was held at Stockholm, there being present 361 members representing 18 countries. The United States government was represented by an army officer and a navy officer, and the American Society of Mechanical Engineers by a delegate. The congress continued in session for three days, reports of committees were presented, papers read and discussed, and plans outlined for the future work. It was resolved that the next congress should be held in Paris in the summer of 1900, and the council was authorized to appoint technical committees to make reports at that time on special problems relating to the objects of the Association.

At a meeting of the International Council held early in 1898 appointments were made of chairmen of 21 committees on technical problems, and the number of members on each committee from each country was assigned. It was also recommended, in order to expedite the appointment and work of these committees, that the members in each country should meet and form a national section of the International Association. In compliance with this recommendation a number of the American members met on June 15, 1898, and organized an American Section, whose first annual meeting was held at Philadelphia on Aug. 27, 1898, and whose second annual meeting I now have the honor to address.

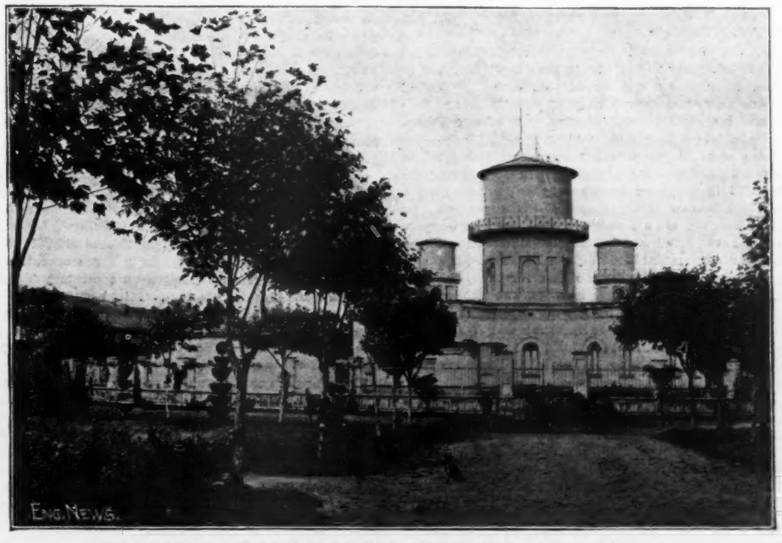

FIG. 6.—VIEW OF ASTRONOMICAL OBSERVATORY AT QUITO.

The membership of the International Association numbered 493 in 1895, 953 in 1896, 1,169 in 1897, 1,488 in 1898, and is now probably about 2,000. Germany takes the lead in regard to number of members, it having 387 in 1898,

*An address by Prof. Mansfield Merriman, Chairman of the American Section of the Association, at the second annual meeting held in Pittsburg, Pa., August 15-16, 1899.

while Russia had 315, Austria 158, England 83, Switzerland 83, United States 68, Sweden 68, France 66, Holland 48, Norway 42, Denmark 39, Spain 36, Italy 35 and 60 from nine other countries. With regard to the American membership, it may be noted that it numbered 6 in 1895, 25 in 1896, 60 in 1897, 68 in 1898 prior to the organization of the American Section, 106 in February, 1899, and that it is now nearly or quite 125.

There are two peculiarities regarding membership in this Association that deserve notice. First, there is no nomination or election of members, but any person desiring to be a member may do so on signing a statement that he assumes membership and will be governed by the laws of the Association; in so doing he further assumes the obligation, stated in Art. 5 of the statutes, that he will advance its interests to the best of his ability. Membership is hence a voluntary act assumed by an individual in order to promote the knowledge of the properties of materials and to endeavor to secure uniformity in methods of testing them. Withdrawal from membership may be made at any time by mere announcement to the proper officer of the Association.

The second noteworthy feature regarding membership is that it may be assumed by a corporation or society as well as by a person. For example, in the list of members of the American Section, published in February last, will be found the Franklin Institute, the American Society of Mechanical Engineers, the American Foundrymens' Association, and five local engineering clubs, as also several steel companies, engineering journals, and firms engaged in inspecting and testing. In Europe this feature is carried much further, the membership of the German section including the bureau of public works of several cities, provinces and states, the police bureau of Berlin, the Prussian war department and the boards of direction of numerous railways, as also a large number of manufacturing corporations and engineering societies. Under this arrangement it is possible for a corporation to exert a greater influence than through the indirect individual membership of its president or superintendent, both manufacturers and consumers can make their wishes more directly known, and thus differences in regard to methods of inspection and testing can be more quickly harmonized than under the usual plan of strict individual membership. However, fully three-fourths of the total members are individuals, and these include engineers in all branches, architects, chemists, professors of mechanics and engineering, and superintendents and foremen of works.

At the Zurich congress the dues of members were fixed at $1 per year, and while no change was made at the Stockholm congress, the council recommended early in 1898, in view of the heavy expenses, that each member should pay $1.50 per year. Accordingly, at the first annual meeting of this Section, when our present by-laws were adopted, the provision was inserted that each member should pay $2.50 per year, of which $1.50 should be transmitted to the International Association and the remainder be used to defray the expenses of the American Section. This by-law went into effect on Jan. 1, 1899, and accordingly no dues were collected by this section for the year 1898, the $1.50 payable for that year being forwarded to the International Council directly by each member or through the American member of that council. During the present year dues have been paid directly to our Secretary, and his report, together with that of our Treasurer, will be laid before this meeting.

The dues of $1.50 per year per member transmitted to the International Council are used by it in issuing its publications and in assisting its committees in defraying a part of the expenses of their special investigations. In addition to this income a number of societies and bureaus have agreed to make extra annual contributions, the Prussian war department heading the list with $125, and 21 others giving smaller sums, so that for the year 1898 the amount derived from these sources was about $400. Although official information is not at hand, it is safe to say that the total income of the International Association for the year 1898 did not exceed $2,000, which is certainly a small sum with which to issue its publications and carry on the work of 21 committees.

The International Association has issued yearly since 1895 a list of members, and also abstracts of the proceedings of the congresses of 1895 and 1897. These, together with a few circulars of information, constitute all the publications that it has been able to furnish free to its members. The detailed proceedings of the congresses have been printed in the journal "Baumaterialienkunde," published in the French and German langauges, at Stuttgart, which has been furnished to members at $2.50 per year, the regular subscription price being $3.50. It will be seen, therefore, that an American member who desires to be fully informed regarding the work of the Association must necessarily subscribe to this journal, and by so doing his dues become really $5 per year. It should further be stated that arrangements will probably be made so that the official announcements of the International Council and the proceedings of future congresses will be printed in this journal in the English language, as well as in German and French.

The American Section, as already stated, had no income during 1898, and the report of our Treasurer shows that during the present year the amount available for expenses has been about $120. On Feb. 18 a pamphlet of 26 pages was issued containing a list of officers of the International Association and its committees and a list of the American members, together with the statutes, by-laws and some historical information. In April a bulletin was issued giving abstracts of the proceedings of the first annual meeting and of the meetings of the executive committee, and in July a second bulletin was issued containing the preliminary programme for this meeting. It is hoped that the condition of our treasury may permit these bulletins to be continued, and that one may be issued containing the proceedings of this meeting.

The technical questions proposed for discussion at the Paris congress of 1900 are 19 in number. The organization of the international committees which are to consider these topics is now complete, and preliminary reports from the American members of several of them are to be presented and discussed at this meeting. Probably the most important of these subjects is that of standard international specifications for testing and inspecting iron and steel; this committee originally consisted of about 40 members, of which five were assigned to this country, but under authority to increase its numbers the American sub-committee has been increased to 21, has held several meetings, collected specifications, and will present a preliminary report of much interest. It is also expected that the American members of five other international committees on iron and steel will report progress in their organization and work. As the national sub-committees are now in full correspondence with the international chairmen, it is expected that the final reports which are to be presented for discussion at the Paris congress will prove of great interest and value.

Of the 19 problems to be considered by the 19 international committees six are on iron and steel, one on stone and slate, eight on cements and mortars, one on tile pipe, one on paints, one on lubricants, and one on the dry rot of wood. The fact that there are eight committees on cements and mortars and only six on iron and steel may seem abnormal, but it should be remembered that in the testing of hydraulic cement the personal equation of the observer enters to a far greater degree than in the case of metals, and that its rapidly increasing use demands the immediate perfection of methods which will render comparable the work of different laboratories. At the session to-morrow morning preliminary reports from some of our sub-committees on these questions will be presented.

While the main object of the Association is to establish standard rules for testing, it is recognized that this cannot be done until a thorough knowledge is obtained of the properties of materials under varying conditions. Accordingly the work of some of the committees is to collect and digest the information now on record, or to make scientific investigations that will render present knowledge more complete and definite. Thus, there is a committee on the properties of steel at abnormally low temperatures, one on the relation of the chemical composition of stone to its weathering qualities, one to digest the work of previous conferences and conventions on the adhesion of hydraulic cement, one on the causes of the abnormal behavior of cements as to time of setting, and one on the protection of wood against the action of dry rot. Some of these subjects have already been discussed at the congresses of Zurich and Stockholm, and accordingly the reports to be presented to the Paris congress should contain positive additions to present knowledge.

At the annual meeting of this section, held last year, the desire was expressed to discuss the subject of impact tests, and a special committee was appointed whose report will be presented at this meeting. Later, other members requested that other problems should be taken up by the section, and accordingly three other American committees have been organized on special problems connected with the manufacture of iron and steel. While these committees have no connection with the international ones, it is believed that their work will add to the interest of our annual meetings, and further the general objects of the Association.

There are advantages and disadvantages in doing technical work by committees. One advantage accrues through the harmonization of the different views held by individuals, whereby non-essentials are rejected and only fundamental methods retained. One of the disadvantages is that this process of harmonizing views takes time, causing reports to be long delayed, particularly with international committees. Some technical societies appoint committees with great reluctance, fearing that their reports may be regarded as official action. In the case of our international organization, no such fear is felt, and the report of a committee is to be considered from the same point of view as the paper of an individual member. Through the formation of the national sections, the work of the international committees can certainly be made more valuable and effective than ever before, for each national sub-committee, after having eliminated disagreements of its individual members, can work as a body to impress its views upon the other national sub-committees. In many cases an international agreement may be found difficult to make, but if made after such full discussion it will be sure to be authoritative and valuable.

The subject of the chemical analysis of iron and steel has been discussed in previous conferences and congresses, and at the Stockholm meeting of 1897 it was formally resolved to establish an international sidero-chemical laboratory at Zurich. It was stated that fifteen smelting companies and iron manufacturers had pledged themselves to contribute $3,500 per year for this purpose, and that the Polytechnicum at Zurich had offered the use of four well-equipped rooms. It was, accordingly, determined to open the laboratory in 1898, and an international commission was appointed to take charge of it and raise further funds for its maintenance. I am unable to state how fully this has been carried out, as no published accounts of its work have appeared. It is, however, to be doubted whether the establishment of chemical and physical laboratories falls properly within the scope of the objects of the association. If sufficient funds could be raised so that men of different nationalities might meet at such a laboratory to actually make analyses and tests, each criticizing the others, while at the same time learning from them, then undoubtedly effective work would be done in harmonizing differences and perfecting standard methods. It is to be hoped, if the establishment of the sidero-chemical laboratory at Zurich proves to be successful, that it may tend to further this method of research. It is, however, the opinion of many members that results as good, if not better, would be secured by arranging systematic schemes of investigation and distributing the actual work of analysis or testing among the laboratories of different countries.

A brief history of the organization and work of the International Association for Testing Materials, and of that of its American Section, has now been given. The great interest taken in the movement in so many countries is an index of the necessity felt in all branches of the engineering profession for the introduction of uniform methods of testing and inspecting the materials of construction. This work is one that must occupy many years, and which in a certain sense can never be finished, for constant progress will be made in our knowledge of the properties of materials. In order to carry it on with success it is apparent that more money will be needed than the small amount now raised from the annual dues of members. In Europe the importance of the work of the association is forcibly attested by the fact that engineering societies, bureaus of public works, iron and cement manufacturers, and railroads assist it by extra annual contributions, and it is to be hoped that the influence of this section may be sufficient to cause similar substantial gifts to flow into its treasury from American corporations.

Since the above was written a circular of the International Council has been issued, containing the information that probably arrangements cannot be made for holding the congress of the Association at Paris in 1900. It appears that the authorities of the Paris Exposition have the right to control the organization of all congresses held in that city in that year, and that they have announced one to be held on the subject of materials, and appointed officers to conduct the same. The subject will be discussed at this annual meeting, and expressions of opinion are desired as to whether it is best to abandon our congress of 1900, in order to co-operate with the one announced by the authorities of the Paris Exposition, or to hold it at London during the week preceding.

In conclusion, it is with pleasure that I congratulate the American Section upon its activity and the Association itself upon the bright prospects before it. The undertaking inaugurated by Bauschinger and his associates bore good fruit at the conventions of 1884, 1886, 1888 and 1893, and prepared the way for the Zurich meeting of 1895, which was at the same time the fifth convention and the first congress. At the Stockholm congress of 1897 the true international work was begun, and the problems there proposed are now the subject of careful study in all parts of the earth. Let us hope that the reports to be presented at the future congresses will be such as to add to the present stock of knowledge, prove advantageous to both producers and consumers, and assist all engineers in economically using the materials and forces of nature for the benefit of man.

SPECIAL STEEL CAR FOR TRANSPORTING HEAVY LOADS; NORTH BELGIAN RAILWAY.

(With two-page plate.)

We illustrate on our two-page plate this week the general details of a special steel car for heavy concentrated loads, designed by Mr. J. Koechlin, Engineer of Materials, North Belgium Railway System, and put in operation on the lines of that system in January, 1898. While cars of this character are not novel in America, it will, we think, interest American motive power officials to examine French methods of solving this particular problem of car construction. According to the description given by Mr. Koechlin in "Revue Generale des Chemins de Fer," from the March number of which we reproduce the accompanying illustrations, quite a variety of conditions had

to be met in designing this car. It was required first of all that it should be able to carry a total load of 35 French tons (78,140 lbs.), of which 25 tons (56,100 lbs.) should be concentrated over a length of 2.5 m. (8.2 ft.) at the center of the car, and that it should also be able to pass curves of 50 m. (164 ft.) radius, or about 35° curves. These loads were to be of a very diverse character, comprising heavy castings and pieces of machinery

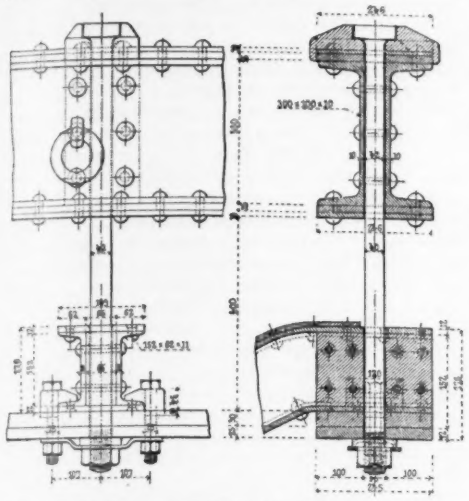

Fig. 10.—Detail of Support for Suspended Cross Frames.

often of irregular shape, long girders, beams and structural materials, railway rails, etc. Finally it was necessary to secure such simplicity of construction that the car could be built in the regular car shops of the company.

Figs. 1 to 10, inclusive, show the construction of the car as designed. As will be seen, Figs. 1, 2 and 3, the main longitudinal members, are the side sills, which are of heavy I-section, and as is usual in European cars, they receive the entire strain of the buffing shock. These side sills are connected by the channel section end sills, Fig. 4; by the body bolsters, Figs. 5 and 6, and by eight intermediate cross frames, Figs. 7, 8 and 9. Referring to the cross frames coming next to the body bolsters, it will be seen that each consists of two parts, first a strut of box section, bracing apart the side sills proper, and second a web plate which strengthens the gusset-like reinforcement of the side sills. Figs. 2, 7 and 8 show this cross frame construction in detail, and with Fig. 1 also explain the gusset plate construction. As will be seen, these gusset plates are the connections for the three body truss rods under each side sill. The two upper truss rods are round at their connections, but flatten out before passing under the cast-iron truss rod bearings and the four intermediate frames at the center of the car, while the lower one is a flat plate the full width of the side sill, and passes under and helps support all six intermediate frames. A similar flat truss rod is anchored to the body bolster at the center and passes under and helps support all eight cross frames.

The ends of the car up to the main cross frames are floored, but the center portion is open and the six intermediate cross frames are suspended below the level of the side sills to give great head room for the loads. Fig. 9 shows the construction of these intermediate cross frames. The four center ones can be removed from the car by removing the hanger bolts and the clamp bolts, Fig. 10. It will be noticed that these hanger bolts fit loose where they pass through the side sills, and the end castings of the cross frames, so as to relieve the side sills of torsional strains and keep the bolts always in tension. These hanger bolts are aided in supporting the cross frames by the body truss rods at the sides and center of the car. The duty of the clamp bolts is to hold the end casting of the cross frame firmly in its position on the side truss rods.

Further details of the car body construction are explained by the drawings. The material of the riveted members is wrought iron, having an ultimate strength of 40 kgs. per sq. mm. (56,892 lbs. per sq. in.), with 20 to 25% elongation in 200 mm. (4 ins.), but a somewhat weaker material was used for the tie rods, draw bars, etc. All castings are of steel and have an ultimate strength of 50 kgs. per sq. mm. (71,116 lbs. per sq. in.), with from 15 to 20% elongation.

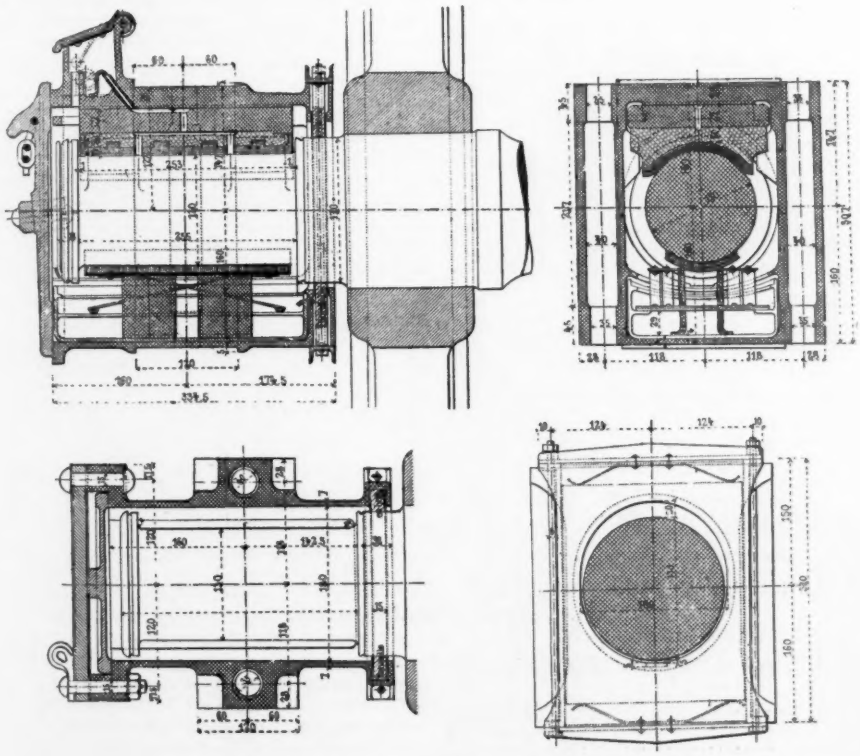

FIG. 11.—DETAILS OF JOURNALS AND JOURNAL BOXES.

The load coming upon the truck springs when the car has its full load of 35 tonnes amounts to about 12,536 kgs. (27,579 lbs.) upon each of the four groups of springs. It was furthermore impossible because of lack of room to give the springs much height or play, and each group of four springs has a deflection of only 5 mm. (0.2-in.) per tonne (2,204 lbs.). This subjected the car body or underframe to severe torsional strains from inequalities in the roadbed and other causes, and the attempt was made to remedy this objection by constructing a special form of bearing on the trucks. These bearings are shown in detail in Figs. 5 and 6. Referring to Fig. 5 first, it will be seen that the body bolster carries a socket casting which fits onto a ball pivot carried by the truck bolster, which rests upon the truck springs in the usual manner. At this end of the car the bearing is, therefore, a single pivot bearing. At the opposite end, however, two side roller bearings convey the weight of the body to the truck springs, as clearly shown by Fig. 6. The truck springs carrying the pivot bearing are single 30 mm. springs, but those for the other truck, since they have to counteract the tipping loads of the car body, are reinforced by interior springs of 18 mm. diameter material. Fig. 11 shows the journal box construction, which it will be noticed possesses several novelties. The brasses are held in place by sliding wedges, which can be removed to enable the brasses and other wearing surfaces to be examined. The brasses themselves are bushed with "white metal" of the following composition, tin 84%, antimony 11%, and red copper 5%. The journal boxes are of cast steel. It will be noticed from Fig. 1 that one truck is provided with a hand brake.

In making the calculations for the different members of the frame subjected to flexure a maximum fiber strain of 6 kgs. per sq. mm. (8,533 lbs. per sq. in.) was adopted. The assumed load of 35 tonnes was considered to be distributed in the proportions of 6,250 kgs. (13,750 lbs.) applied at the middle of each of the four center cross frames, and of 5,000 kgs. (11,000 lbs.) on each of the next two. For tie rods and other pieces subjected to tension only the maximum fiber strain allowed was 10 kgs. per sq. mm. (14,223 lbs. per sq. in.). The total weight of the car as built was 23,686 kgs. (52,109 lbs.).

COVERED RESERVOIRS AT PASADENA, CAL.

By T. D. Allin.*

Pasadena has six reservoirs, all of which are cement-lined, and all of which are now covered, five being covered with flat roofs.

Until covering was resorted to a great deal of trouble was experienced each year by the growth of algae, which grew very luxuriantly during the months of April and May, and which, when decay set in, impaired the quality of our water, which in all other respects was excellent.

About six years ago the North Pasadena Land & Water Co. covered a small reservoir with a pitch roof. In the spring of 1896 the Pasadena Land & Water Co. covered its two reservoirs, one of 4,500,000 gallons capacity, and the other of 1,500,000 gallons capacity. The two latter reservoirs were covered with flat roofs, supported on wooden posts, and the roof boards were run east and west, with battens over cracks.

In the spring of 1897 the Pasadena Lake Vineyard Land & Water Co. covered its smaller reservoir of 4,000,000 gallons capacity. Two-inch water pipe were used for posts. The boards were run north and south, and the cracks were left uncovered. About the same time the North Pasadena Land & Water Co. covered its second reservoir of 750,000 gallons capacity. It ran the boards north and south, and left cracks uncovered, but used wooden posts.

Owing to the good results from covering, as shown by other reservoirs, the Pasadena Lake Vineyard Land & Water Co. decided to cover its large or Villa St. reservoir of 21,000,000 gallons capacity. On account of the foulness of the water this reservoir was abandoned in the middle of last summer, the algae then showing a more luxuriant growth than ever before. This no doubt was partly caused by a scarcity of water, preventing the reservoir being kept filled to the depth of former years.

The reservoir is 330 × 540 ft. in its greatest dimensions, and varies from 17 ft. to 19¾ ft. in depth. The north end is circular and the east and west sides converge slightly toward the south, the

*Engineer Pasadena Lake Vineyard Land & Water Co.

south end being approximately at right angles to the sides. The side slopes are 1 to 1. The sides and bottom are lined with 1 to 6 cement concrete, 3½ ins. thick, and then surfaced with 1 to 1 cement ½-in. thick. The covering was completed Jan. 1, and was effected as follows:

Two-inch water pipe (asphalt dipped) was used for posts, which are 18 ft. apart from north to south, and 15¾ ft. apart from east to west, as shown by Figs. 1 and 2. Upon these posts are 6 × 6-in. corbels, 30 ins. long, held in place by the posts fitting tightly into auger holes in the corbels 4 ins. deep. Resting upon the corbels, running north and south, are 4 × 10-in. × 18-ft. girders,

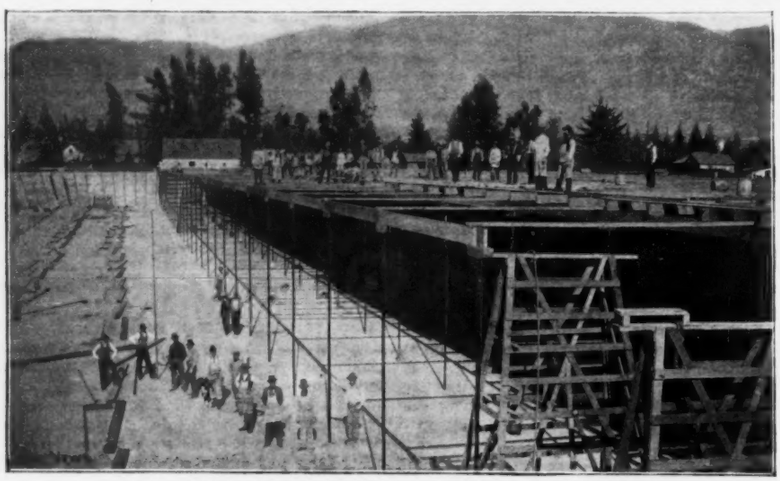

FIG. 1.—COVERING THE VILLA ST. RESERVOIR, PASADENA, CAL.
T. D. Allin, Engineer Pasadena Lake Vineyard Land & Water Co.

consisting of two 2 × 10-in. planks spiked together. The end of one plank extends 1 ft. past the end of the plank to which it is spiked. This end laps, and is spiked to the projecting plank of the next girder, making the girders continuous from one end of the reservoir to the other.

Upon the girders, running east and west, are 2 × 8-in. × 16-ft. joists, 6 ft., c. to c. The girders being 15¾ ft., c. to c., the 16-ft. joists overlap from 4 to 5 ins., and are spiked together at the lap.

Upon the joists, running north and south, the roof boards are placed. The boards are 1 × 12 ins., 12, 18 and 24 ft. long, and were placed close together, but after exposure have left cracks from ⅝ to ¾-in. wide. The cracks are not covered, such sunlight as passes through them having been found to be of no detriment. On top of the roof boards, directly over each joist, running east and west, a 1 × 4-in. strip is nailed, which to a great extent prevents the warping of the roof boards.

The posts are capped at the bottom and are water-tight. They rest upon the cement bottom of the reservoir, except on the side slopes, where footings were cut out and cemented over again after the posts were in place. Around the foot of each post resting upon the bottom of the reservoir a cement ring is run, which holds it in position, but is not really necessary.

The bottom of the reservoir not being level, contours 4 ins. apart were run, and from the contour map the posts were ordered from the manufacturers in such lengths as not to waste more than 4 ins. on any one post. The position of each post was marked on the bottom of the reservoir with transit and tape. A platform was built in the reservoir near one side on which was stationed a man and level. The level was set at the plane of the tops of the posts. The rodman, with an extension rod made for the purpose, took levels at each point designated on the bottom of the reservoir, marking each post as the levels were taken, and designating each post by letters and figures to correspond with large letters and figures on the sides of the reservoir at the ends of the rows. The pipe cutters then followed, and after cutting, placed each post ready to be erected by the erecting gang.

The planks for girders were cut in a form, as were also the roof boards. Each post was carefully plumbed, and then held by a joist laid flat and temporarily spiked to the girders, as shown in the view, Fig. 1 (from a photograph taken in December, 1898). The position of each joist on the girders was marked by the use of a steel tape, every third joist resting directly over posts.

The erecting gang consisted of seven men, one of whom worked on top of the structure to place and then nail the temporary joist as soon as the post was plumb. They would erect from 1,500 to 1,600 ft. of girders per day. This gang was closely followed by one placing the permanent joists, and it in turn was closely followed by the roof gang, so that the work was kept close up to the erecting gang from start to finish.

No bridging was used, and no bracing except on the east and west sides, as shown in Fig. 2. However, the entire side was thoroughly anchored at the beginning of the work to prevent transverse vibration, but the anchorage was removed as soon as the work reached the opposite bank. With from 30 to 40 men on top, carrying and nailing lumber, no vibration was noticeable.

With the exception of some minor work, the job was done in eight days. All lumber was rough, merchantable Oregon pine, of which 259,966 sq. ft. were used, at an average cost of $18.68 per

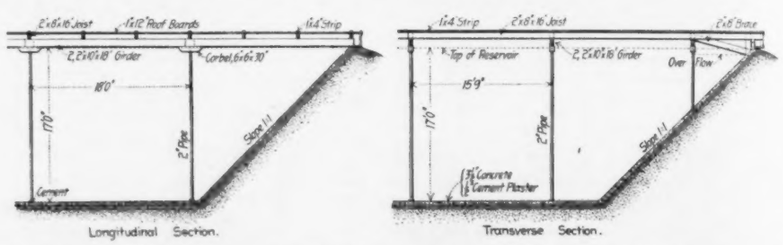

FIG. 2.—LONGITUDINAL AND TRANSVERSE SECTIONS THROUGH ROOF OF VILLA ST. RESERVOIR, PASADENA, CAL.

1,000 ft., delivered at the work. The cost was as follows:

259,966 sq. ft. of lumber	$4,856
9,373 ft. of 2-in. pipe for posts (including 551 caps and freight)	987
Hardware	203
Mill work (labor making corbels)	27
Cement (around foot of posts)	6
Engineering	151
Labor (including superintendence)	1,004
Total	$7,234

The cost was $48 less than the engineer's estimate. The area covered was 166,000 sq. ft., at a cost of 4.36 cts. per sq. ft., or $345 per 1,000,000 gallons of storage.

The plans were drawn by the company engineer (the author of this article.—Ed.), under whose supervision the work was done, with Mr. E. H. Royce, one of the directors of the company, superintending the construction work.

Water was turned in about Feb. 1, and the reservoir was full about March 1. For a few days since that date the water fell to a depth of 10 ft., but has been at from 15 to 16½ ft. in depth the remainder of the time. Not the slightest trace of algae or other vegetable growth has since been detected (up to July 1, 1899), an object as small as a pin being visible on the bottom. The same may be said of all reservoirs covered here, the result being equally favorable whether cracks have been covered or left uncovered.

The water supply of the Pasadena Lake Vineyard Land & Water Co. was originally from springs at the Devil's Gate in the Arroyo Seco, one mile from the base of the mountains and three miles northwest of the center of Pasadena. Later, tunnels were run under and tapping the springs, with one of the tunnels passing under the Arroyo channel on bed rock, and the others running under the mesa lands, approximately at right angles to the tunnel. There are four tunnels in all, with an aggregate length of 6,218 ft. These tunnels pass through a granite ledge for distances of from 100 to 300 ft. before entering the water-bearing gravel under the mesa lands. At favorable points in the rock the tunnels have been sealed, and the flow of water controlled by valves set on pipes passing through the dams.

Previous to the sealing of the tunnels the surplus water, which during some winter months was 75% of the supply, ran to waste, but now when the supply is greater than the demand the valves are used to regulate the flow, holding the surplus in store, and materially increasing the summer flow. In each dam, just over the water pipe, a manhole is left, with trap-door held closed by the water pressure behind it. These holes are for the purpose of ventilation, the doors being kept open whenever the water is drawn down in the tunnels.

From the tunnels the water is conducted in a 22-in. steel pipe to the smaller reservoir, from which about 63% enters the distributing system, the remainder being carried to the large reservoir described in this article, which holds about a month's supply for the district covered.

(Pasadena is supplied with water by three or four companies, the bulk, if not the whole, of the supply being developed from underground sources. For the convenience of those interested, we append a list of references to articles on covered reservoirs, which have appeared in Engineering News during the past ten years. The list does not include covered filter beds or covered reservoirs for the reception or storage of sewage.—Ed.)

Denver, Colo., Sept. 29, 1888.—Reservoir in embankment, with maximum water area 120 × 559 ft. Wooden posts, 6 × 6 ins., maximum height, 24 ft., supporting 3 × 8-in. girders, 3 × 12-in., joists and 1-in. boards forming the covering.

Covered Reservoirs, Feb. 16, 1889.—General review, with brief descriptions of a few foreign examples.

Hudson, Wis., March 15, 1890.—Stone side walls lined with brick, 48 × 60 ft. inside; brick piers and arches.

Pierre, S. Dak., June 21, 1890.—Reservoir in excavation, 150 ft. in diameter; masonry side walls and central pier; trussed timber roof, 30-ft. rise.

Coshocton, O., Aug. 15, 1891.—Stone wall, 50 ft. inside diameter, covered by a domed brick roof of about 14-ft. rise.

Franklin, N. H., May 12, 1892.—Stone walls, 70 ft. average diameter, covered with brick, there being an inner dome 23 ft. in diameter and two concentric arches, of about 11 ft. span.

Covered Service Reservoirs, Sept. 14, 1893.—Abstract of paper relating largely to East Indian practice. For full paper see Proc. Am. W.-Wks. Assoc. for 1893.

Waltham, Mass., Dec. 21, 1893.—A central well, 41⅔ ft. internal diameter, covered by a tile dome of 7-ft. rise; the well is surrounded by a reservoir, whose greatest internal dimensions are about 70 × 95 ft., covered by brick arches.

Brookline, Mass., Dec. 21, 1893.—About 92 × 94 ft., covered with brick arches.

Albany, Ga., Feb. 8, 1894.—Circular, 60 ft. in diameter, covered with a conical-shaped wooden roof, about 8 ft. high, inside.

Rockford, Ill., Feb. 22, 1894.—About 60 × 150 ft., inside; concrete bottom and side walls covered by a single concrete and expanded metal arch, with tie rods.

Bordeaux, France, March 22, 1894.—Elevated iron structure, in two compartments, each about 55 × 125 ft. long, with tile roof on wooden rafters, supported by iron trusses of 55-ft. span. There is a thin exterior wall of ornamental brick.

Columbo, Ceylon, Aug. 9, 1894.—Repairs to the Maligakanda service reservoir. Describes cracks in a concrete reservoir, due to contraction and expansion. Further discussion was given in Eng. News for Sept. 27, 1894. The reservoir was described in Proc. Inst. C. E., Vol. LXXIII., in a discussion on a paper entitled "Covered Service Reservoirs."

Fuenfkirchen, Transylvania, Aug. 16, 1894.—About 50 × 80 ft., inside, covered with concrete arches.

Vienna, Austria, May 21, 1896.—Extension of reservoir, 220 × 637 ft., inside, divided longitudinally into two compartments; covered with brick arches, provided with conical openings, set with glass, for lighting interior.

Oakland, Cal., Nov. 5, 1896.—About 100 ft. sq. No details; article referring to break in side wall, due to defective construction of addition to original height of wall.

Wellesley, Mass., Sept. 30, 1897.—Internal diameter, 82 ft.; concrete walls and roof, latter composed of groined elliptical arches. A portion of this roof fell during construction.

Quincy, Ill., June 9, 1898.—Reservoir in embankment, 317 × 415 ft., on top, 26 ft. deep; covered with timber. Posts 6 × 6 ins., 14 ft. c. to c. transversely, and 18 ft. longitudinally. Girders and floor joints carry 1-in. board covering.

Indianapolis, Ind., June 23, 1898, in report of Convention of Am. W.-Wks. Assoc.—About 1,000 ft. long, average width 50 ft., and maximum width, 70 ft.; 4-in. cast-iron pipe for posts or columns, 6-in. wrought-iron pipe for girders, 2 × 12-in. timber joints, and 1 × 3½-in. yellow pine boards.

INFLUENCE OF THE LENGTH OF SPAN IN TRANSVERSE TESTS OF CAST-IRON.

By Dr. R. Moldenke.*

In the transverse tests made by the American Foundrymen's Association Committee with Sets A, B and C,† the distance between the supports for the bars was always taken at 12 ins., the bars themselves being but 2 ins. longer. This distance was selected after a careful consideration of the subject. It is a convenient length for such tests; the foot moreover is also a unit of distance; the bars can be cast vertically without trouble, and their weight is not excessive.

As the bars selected for the transverse test in a full set number 128, one can readily imagine the difficulties which would be encountered in attempting to get them 3 ft. or even 5 ft. long. A bar 4 ins. square and 5 ft. long would be a cumbersome thing to test.

An important consideration influenced the adoption of the foot as a standard distance between supports of these tests, and that is the well-known fact that with a given testing speed the longer the bar the less searching the test. A 5-ft. cast-iron bar will support a very much greater load before breaking if this is applied gradually without the least jar than it will if the load is put on quickly and with shocks. In the latter case the bar simply has no time to adjust itself to rapidly changing conditions which may require twice as much resisting power on its part than it needs under the static load, and hence it breaks much before it would have done had it been able to yield slowly as the pressure increased. On the other hand, it is also known that with perfectly steady loads the quicker they are applied the higher the results, though this is more marked in the elastic materials than in cast iron. With our testing machines, as usually constructed, the question of speed is such that it is better to test a short bar slowly than a long one fast. Again, the service conditions of cast iron are of a kind that make it desirable to know how it will behave under quickly applied loads, castings usually failing under shock. To keep the transverse test separate from the impact test (with its special feature of absorbing energy for deformation purposes) and yet take into account this service requirement means a short bar tested quickly.

It was therefore deemed wise to obtain some information on the influence of the length of the bar upon the results from cross-breaking tests. To make the data secured comparable, it was necessary to adopt a system of casting which would bring the required number of test bars under identical foundry conditions. This was accomplished by making six patterns of a 2-in. square bar 16 ins. long. Each pattern was provided with a conical pouring gate at one end, all six being molded gate end up in an iron flask in such a way that the gates were in the bottom of a trough for flushing in a large quantity of metal quickly. The molds were of dry sand, and the cast was repeated with six different heats. In this way a series of bars was obtained in which not only six different tests could be made on material exactly alike, but the same tests could be repeated five times on different heats to obtain good working averages.

For the preparation of this series of test bars the committee is indebted to the generosity of the Frank-Kneeland Machine Co., of Pittsburg, Pa., who went to considerable trouble in making patterns and castings to exactly fulfil the requirements of the case. The tests themselves were carried out as follows: With the same testing speed the six bars of each set were broken transversely, with a distance between supports of 6, 8, 10, 12, 14 and 16 ins. The range from 6 to 16 ins. is a fairly wide one, and, together with the deflections noted, gives a good basis for comparisons.

The following table gives the averages of the results obtained:

Bars 2 × 2 × 16 ins.—Heavy Machinery Mixture.

Average cross section, ins. Depth.	Width.	Supports apart, ins.	Average breaking strain, lbs.	Av. modulus of rupture per sq. in.	Av. deflection, ins.
1.96	2.02	6	34,650	40,000	.063
1.96	2.00	8	25,100	39,070	.070
1.98	2.00	10	18,720	35,660	.064
2.00	1.99	12	16,380	36,970	.080
2.00	1.98	14	13,560	35,900	.094
1.99	1.99	16	11,370	34,380	.096

Representing the average modulus of rupture per sq. in. in the above table graphically we obtain a very interesting curve:

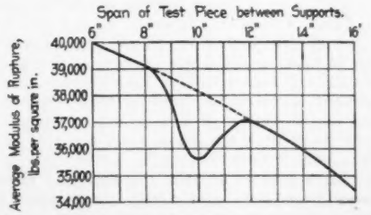

Diagram Showing Results of Transverse Breaking Tests of 2-in. Cast-Iron Test Bars of Different Spans.

But for the 10-in. point the curve would slope downward nearly uniformly. That the break is correct is shown by the same tendency in the curves plotted for each set separately. Whether this break would exist in that place or at all in bars of other cross sections must be left unanswered here. Another interesting speculation would be what influence would result from a testing speed perfectly uniform throughout each test, but increasing as the distance between supports increases (let us say so that for a given time the quotient of the length divided by the deflection remains constant).

It is possible that with a constant testing speed there is a point in transverse tests of cast iron at which the increase or decrease of a fixed ratio between the depth of the bar and the distance between supports (10 ins. divided by 2, or 5 in this case) may mean a change from one set of conditions to another. If this be the case it is evident that the matter will be more serious in heavy bars than in light ones, and that with 10 ins. for the 2-in. square, or heaviest likely test bar, it would be very much less for say a half-inch bar. Now in testing the iron it would be unsafe to accept everything up to this distance of 10 ins., and beyond 10 ins. the results would gradually lose in value the further they went. Therefore the 12-in. distance between supports would seem the safest and yet smallest distance to adopt with bars approaching a fairly heavy cross section, and would very likely be just as acceptable in the case of the smaller ones.

For our purposes, however, it is sufficient that five points out of six are in line, and that therefore the ordinary formulæ used in calculating the cross breaking strength of beams are not only incorrect for cast-iron on account of the chemical differences in the iron itself when in different cross sections, but that with the cross sections identical the distance between the supports must be specially provided for by suitable constants in whatever formulæ may be developed. As seen from the diagram, the doubling of the distance between supports means a drop in the modulus of rupture per square inch of the same iron in the same sized bar of nearly 10%.

Another point of interest is a development from this series of tests. The resilience of the material or its shock resisting power is often calculated from the transverse test by dividing the half product of the breaking load with the deflection by the weight of the bar between supports, the result being the shock resisting modulus in inch pounds per pound of metal. From the table we have

Distance between supports, ins.....	6	8	10	12	14	16
Modulus	176	107	58	53	44	33

or a steady progression downward. As the bars of each set were exactly alike in material and had the same dimensions, their shock resisting quality should certainly be the same, yet the formula regularly employed makes the first result over five times as good as the last. That the shock resisting moduli will be lower for thick sections than for thin ones is known, but that so great a discrepancy should exist with the same dimensioned bars when tested as indicated is surprising.

But one point remains. All the bars were cast vertical. As in the case of casting bars flat, there is a noticeable difference in their strength when tested bottom or top side up, so with the vertical bars there is a feeling that the lower portion might give different results from the upper. The broken pieces of the above tests were therefore again tested transversely, and the results noted. In this case the pieces were all broken transversely with supports 6 ins. apart. While the bars have already been strained beyond their elastic limit (at one end), and the results cannot therefore be accepted as perfectly reliable, yet the comparison is of sufficient value to be worth recording:

The average pressure required to break the upper halves of the 36 bars is 36,560 lbs., as compared with 36,180 lbs. for the lower, a result sufficiently close to be quite satisfactory.

The several points brought out in this study may be of interest to those who care to pursue the subject further, the scope of the work, so far as the committee is concerned, being filled in obtaining the information relative to the use of 12 ins. as the distance between supports of bars tested transversely.

*McCandless and Stanton Aves., Pittsburg, Pa.
†See Eng. News, March 9, April 20, May 18, 1899; pp. 151, 245 and 315.

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Some new facts as to the cheap cost of the carriage of bulk freight by rail are furnished by the annual report of the Chesapeake & Ohio Ry., for the year ending June 30, 1899. We have frequently called attention to the remarkable record which this company has made in reducing the cost of freight carriage, but its achievement in the past year surpasses by far all its previous records. Its average freight rate on all coal shipped to the seaboard in that year reached the astonishingly low figure of 2.21 mills per ton-mile. Coal moved elsewhere was carried for only 3.55 mills per ton-mile, and the average rate on all freight carried other than coal was 4.37 mills. The downward course of freight rates on this road since 1892 is summarized in the following table:

Average Freight Rate per Ton per Mile; Chesapeake & Ohio Ry.

	Mills.							
Year ....1899.	'98.	'97.	'96.	'95.	'94.	'93.	'92.
Coal to seaboard.. 2.21	2.59	2.97	2.53	2.93	3.20	3.27	3.44
Coal elsewhere ... 3.55	3.33	3.80	3.84	3.86	4.43	4.56	4.79
Other than coal ... 4.37	4.37	4.75	5.39	5.26	5.66	6.43	6.30
All freight 3.62	3.70	4.19	4.26	4.25	4.78	5.11	5.36

The manner in which this remarkable reduction in the cost of freight transportation has been effected, we hardly need say, is by increasing the freight train load. During the year just closed the Chesapeake & Ohio carried an average of 425 tons of paying freight on each freight train. This is an increase of no less than 46 tons over the average freight train load of 1898 on the same road; and it places the Chesapeake & Ohio far in advance of any road in this country, or, for that matter, in the world, in the size of its average freight train load. It does not necessarily follow, however, that the Chesapeake & Ohio is actually moving larger and heavier freight trains than other progressive railways. What makes the average train load of the Chesapeake & Ohio so high is the small number of local trains and the small amount of high-class freight which it handles compared with systems like the New York Central, the Pennsylvania or the Lake Shore. Its traffic is to a very large extent through haulage of coal from the mines to the seaboard, and its figures of earnings, therefore, represent present practice in the cheap hauling of low-class bulk freights to an extent which is true of few railway companies.

We respectfully commend this average bulk freight rate of 2.21 mills per ton-mile to the consideration of the Commission which is to advise the Governor of New York what the State had best do with its canals. Hon. Abram S. Hewitt has caused no small commotion among the ardent canal defenders by bluntly confessing that he has seen a great light, and has come, much to his own surprise, to be convinced that the railway can haul freight at less cost than the canal. "No one could have believed it possible," says he, "for the cost of railroad transportation to be reduced to three mills per ton-mile; yet this figure has undoubtedly been reached, and there seems good reason to expect that further economies will bring the cost down to two mills per ton-mile."

It will be seen from the above figures from the Chesapeake & Ohio report that Mr. Hewitt was looking a very short distance into the future when he prophesied a reduction from three mills to two mills. More than three-fourths of this reduction had already been made on a railway system more than a thousand miles in extent before Mr. Hewitt's recent statement was written.

In view of this record, who would set two mills per ton-mile as a limit to the reduction in the cost of hauling freights in the future? Surely larger cars, more powerful locomotives, more permanent and durable track, with all the economies and improvements that future inventors may bring forth will carry the record much below the two-mill rate which Mr. Hewitt regarded as the ultimatum, but to which we are already closely approximating.

"We'll fairly fly, in the by and by," is the heading which we find attached to some recent public deliverances on electricity as the motor for the high-speed trains of the future. It is a little curious how universally it appears to be assumed that if it were desired to run trains at speeds of say 100 miles per hour, electricity would be the power adopted. In the present state of the art it must be said that nothing has ever yet been accomplished in the way of high speed on an electric railway, even experimentally, beyond what the steam locomotive is doing in actual service, week in and week out. The fast schedules on the New York Central and on the Philadelphia & Reading's Atlantic City line have proved that locomotives can be regularly run at speeds up to 70 miles per hour and upward, and that with safety and regularity. If it is desired to increase these speeds to 100 miles per hour, locomotive designers could be found, we are sure, who would undertake to provide a machine to accomplish the work, assuming, of course, that the train load would also be lightened. It is frequently said that the fact that the locomotive is a reciprocating machine, while the electric motor is a rotary one, gives the latter an advantage in the matter of high speeds. As an abstract proposition, this is doubtless true, but the locomotive has by no means reached its limit in the matter of speeds. Larger driving wheels, lighter reciprocating parts, and more careful balancing are some of the means by which higher speeds could be made as feasible as are the speeds at present reached. It is worth noting that none of our present-day locomotives use drivers as large as those in use many years ago on some famous English locomotives of high speed. Another argument occasionally heard is that the high-speed electric motor would be much less severe on the track than the locomotive; but this argument again, is based on theory rather than practice. As a matter of fact, the standard electric railway track now uses a rail nearly twice the depth of the standard steam railway rail, and this practice has been forced upon the electric railways by the impossibility of keeping up their joints with any lighter construction.

Evidently the electric motor designers have also some problems to solve before they will be ready to put in bids for a 100-mile per hour service. The matter of current collection, for example, might prove a hard nut to crack. The trolley is, of course, out of the question, and the heating of a cast-iron shoe sliding on a third rail at a speed of 150 ft. per second might cause some difficulties.

We must candidly acknowledge that the subject is not a vital one at present, for no railway, to run trains at 100 miles an hour, is yet in sight, except in the brains of impecunious promoters. Existing railway lines would find it very difficult for operating reasons to run trains of such high speed on their existing lines, and the proposal to build a special high-speed electric line, even on such much-traveled routes as that between New York and Philadelphia, has never yet been presented to financiers in a way to command their support. It would probably be a much easier task to build either electric or steam locomotives to make 100 miles an hour over such a line than it would be to find sufficient traffic to make it a paying enterprise.

Some of our readers may remember what a vast deal was written a couple of years ago about the competition of Japan with American and European manufacturers. Japanese cheap labor was to inundate us with cheap bicycles, cheap matches, cheap umbrellas and with forty other articles of common use, which would be made and sold at prices far below the cost of production in the United States. It is interesting now to recall some of these alarmist utterances and to compare them with some statistics of Japanese trade, just published by the Bureau of Statistics. These show that Japan imported goods from the United States to the value of 6,090,408 yen (1 yen = 50 cts.) in 1893, and to the value of 40,001,097 yen in 1898. From this showing, Japan appears to have considerably more reason to be appalled at the prospect of an inundation of American goods than we have to fear her competition in our markets. Department stores still seem to find plenty of bicycles to dispose of at prices about the same as those at which the hypothetical Japanese machines were to be sold, and at last accounts our match trust millionaires were in cheerful spirits.

Our "crank drawer" is enriched this week with an exuberant description of a new method of street car propulsion invented by one Benjamin S. Lawson, of Syracuse, N. Y. The "system" consists in equipping the car with an air compressor driven by an electric motor, a set of storage tanks for containing the air, and a couple of compressed air motors. These latter are permitted to drive the car. Various nebulous claims are made for the system, such as that in this way the electricity is used "expansively." Mr. Lawson is evidently of the belief that expansion is popular just now. The only improvement that we can suggest on the invention is that it would be better to go one step farther and equip the car with a steam boiler, engine and dynamo, so that it could generate its own electricity to run the motor. It might be well to add a gas producer and gas engine to run the dynamo when the steam engine was tired, and a horse or two might also be carried along to haul the whole outfit into port in case of necessity. With such a contraption speeding along the rails, Patton, of Chicago, with his gasoline-motor-electric combination, and Heilmann, of France, with his complete central station on wheels, would be completely outclassed.

We wonder how many of our readers have ever heard of the profession of "sugar engineering." That certain mechanical engineers and chemists have made more or less of a specialty of sugar-making machinery and processes, is of course known; but that this field of work had attained to the dignity of being designated as a distinct branch of engineering, we, at least, were quite unaware. There lies before us, however, the circulars of an engineering school—beg pardon, of a University—in which a distinct course on "Sugar Engineering" is announced.

The Dean of the College of Technology, in which this course is given, says that "in a state whose

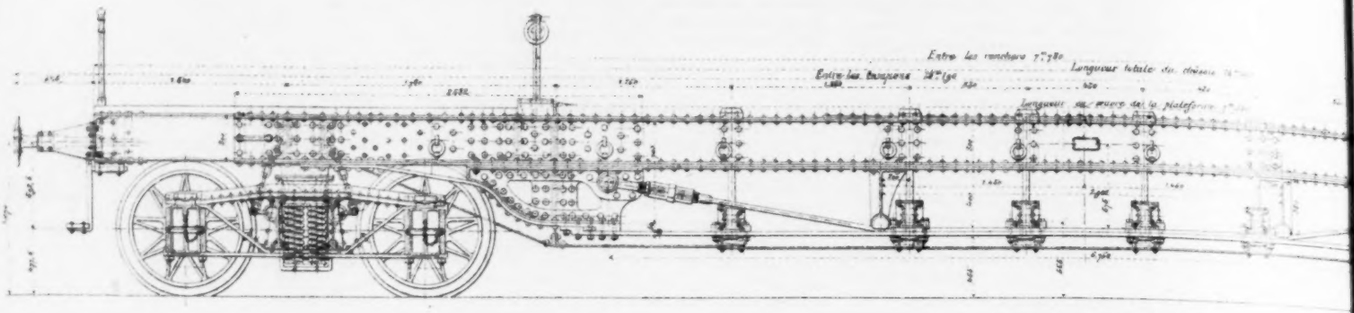


FIG. 1. GENERAL SIDE ELEVATION.

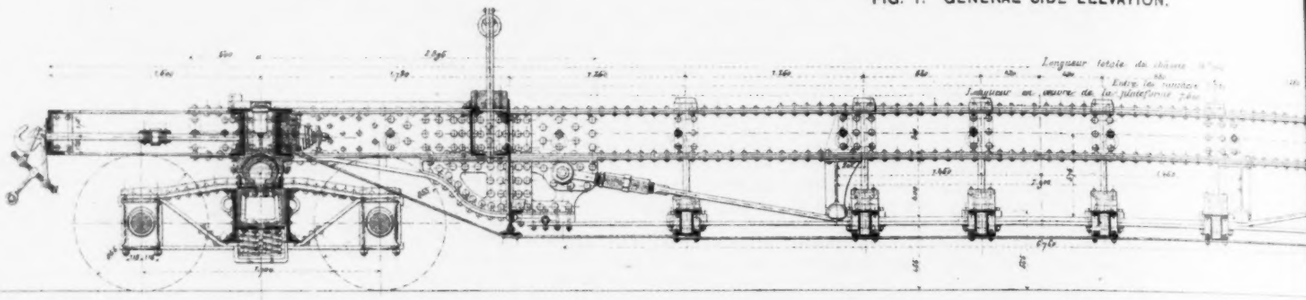


FIG. 2. LONGITUDINAL SECTION ALONG A, B, C, D.

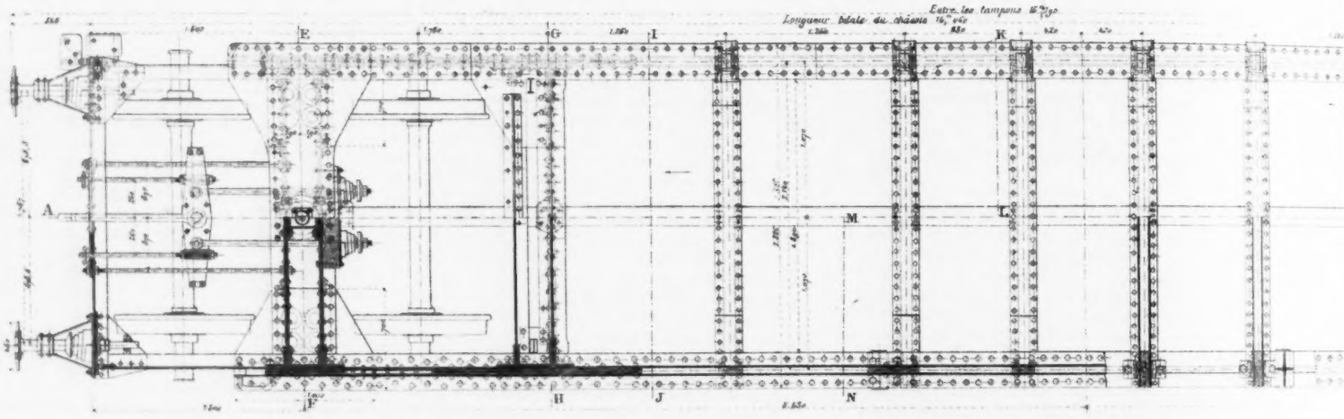


FIG. 3. GENERAL SECTIONAL PLAN.

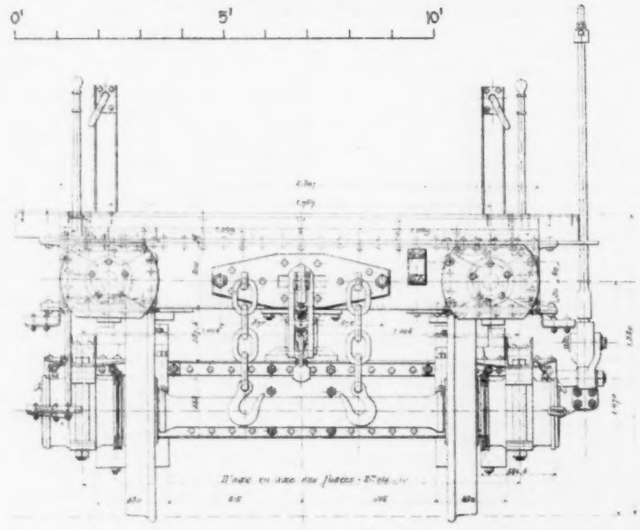


FIG. 4. END ELEVATION.

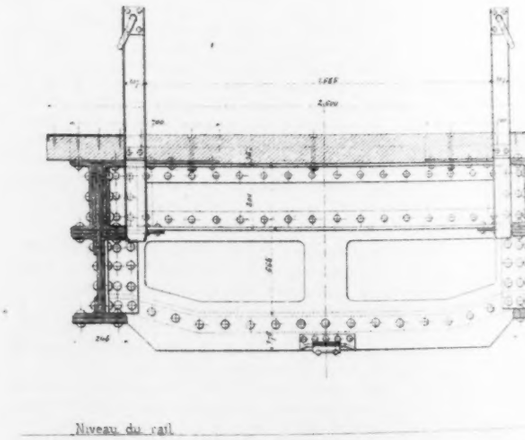
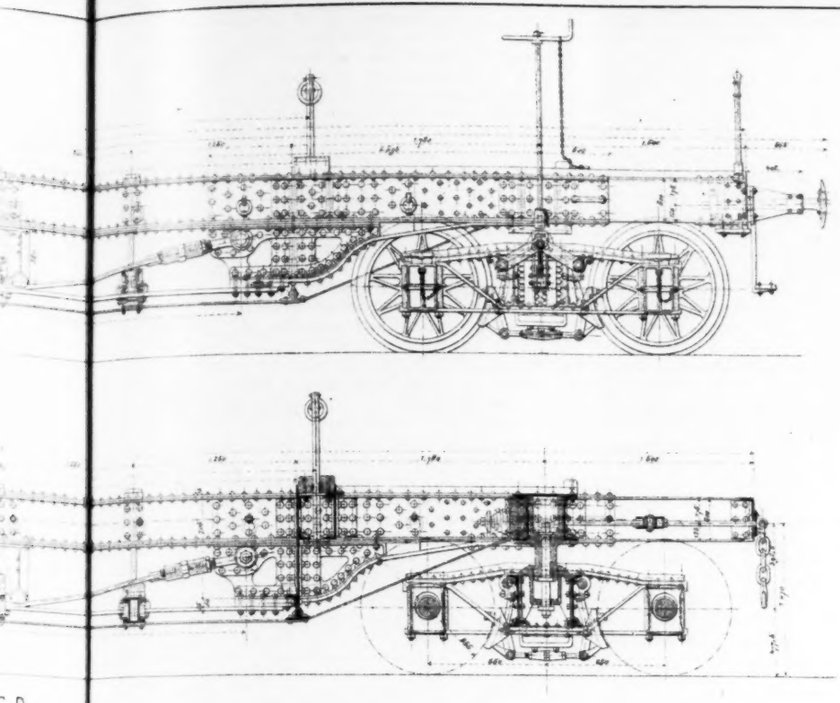


FIG. 7. TRANSVERSE SECTION AT G-H.

STEEL CAR FOR HEAVY CONCENTRATED LOA

J. Koechlin, Engineer of



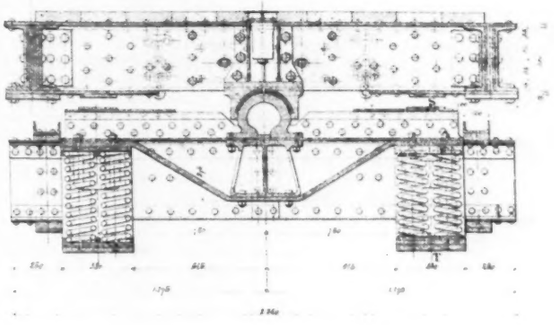
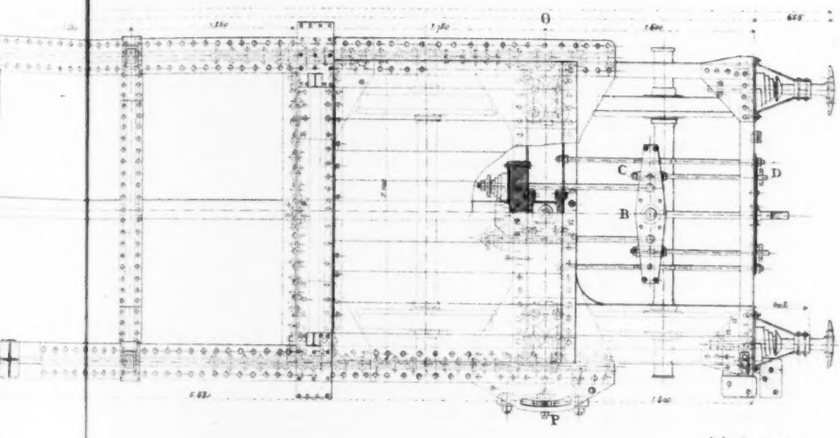


FIG.5. TRANSVERSE SECTION
AT E-F.



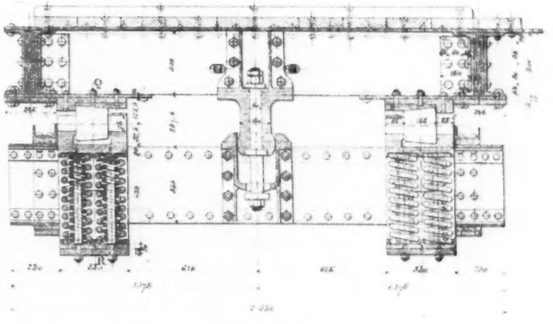
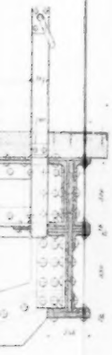
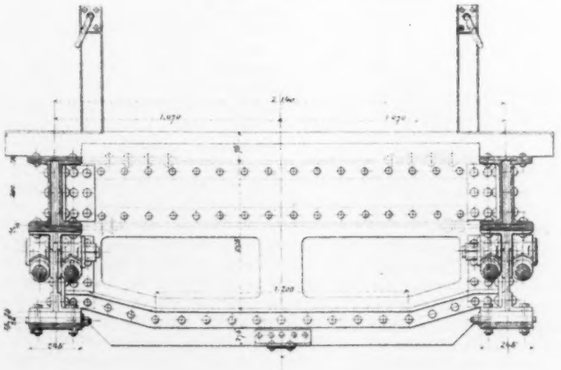


FIG. 6. TRANSVERSE SECTION
AT O-P.

Metres.

0 1 2 3 4 5





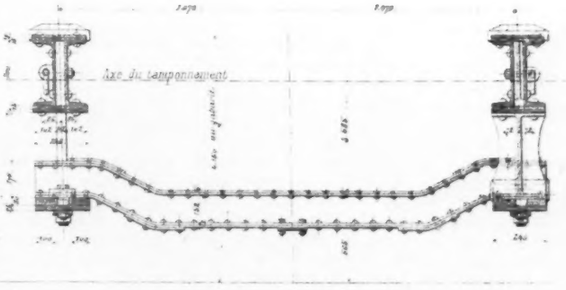


FIG. 9. TRANSVERSE SECTION
AT K, L, M, N.

FIG. 8. TRANSVERSE SECTION AT I-J.

ATED LOADS; NORTH BELGIUM RAILWAY SYSTEM.

Engineer of Materials, Designer.

CHAS. HART, LITH., 86 VESEY ST., N. Y.

main industry is the manufacture of sugar, a technical school which had no course in Sugar Engineering would be like Hamlet without the Prince!" The state, we need hardly say, is Louisiana, and the school is Tulane University, at New Orleans. Whether the student who successfully pursues the studies of this course receives the degree of "Sugar Engineer," or that of "Bachelor of Sugar Engineering," we are not informed.

Recently published photographs of the tornado cloud as it swept down on Kirksville, Mo., on April 27, and alleged to have been taken at a distance of about a hundred yards, have very likely been brought to the attention of some of our readers. In the last number of the "Monthly Weather Review," Prof. A. J. Henry comments facetiously on these alleged tornado photographs, and tells how a photograph was sent to him in 1898 as a photograph of the Waynoka, Okla., tornado of May 17, while another copy of the same photograph, altered only as to the landscape, came along recently, professing to be a bona fide photograph of the Kirksville tornado. Prof. Henry conjectures that the photograph was made by superimposing a photograph of an india ink drawing of a funnel cloud upon a photograph of sunset clouds and landscape. As Prof. Henry aptly says, "it pains us to think that people will take such liberties with the business end of a tornado—and at 100 yds., too!"

So far as we are aware, the only authentic photograph of a tornado cloud ever published was that taken at Oklahoma City, May 14, 1896, and published in our issue of June 11 following. We scarcely need add that that cloud was not photographed at 100 yds. range.

A remarkably cheap reservoir covering is described elsewhere in this issue by Mr. T. D. Allin, Engineer of one of the water companies which supplies Pasadena, Cal. The covering is of light timber, supported by posts of 2-in. pipe. Its cost was only 4.36 cts. per sq. ft., or $345 per 1,000,000 gallons of water stored, the total capacity of the reservoir being 21,000,000 gallons. So light a structure would be entirely out of the question in localities subject to snowfall. At first sight of the view and sections accompanying the article it seems as though a comprehensive system of cross-bracing might have been added with advantage. A closer inspection shows that the timber covering is so tied together as to make it nearly a unit, and there being no load except the very light covering itself, and no chance of wind pressure, the lateral thrust is small.

It is interesting to note that this is the sixth reservoir in Pasadena to be covered, three separate companies owning the structures. One of the water companies at Oakland has a covered reservoir. As early as 1888 a covered reservoir at Denver, Colo., was described in these columns, by Mr. S. Fortier, who predicted that the practice of covering reservoirs would become common in Colorado, at least. The Denver reservoir was large and, like the new one at Pasadena, had a light, flat timber roof. It was designed and built by Mr. C. P. Allen, now Chief Engineer of the Denver Union Water Co. Mr. Allen has been credited with being a pioneer in reservoir covering. One would expect to find records of the covering of a large number of reservoirs in the West and South, where water from underground sources, unless covered, is exposed to very high temperatures when stored, but few such are shown in the list of references which we have appended to Mr. Allin's article. It is not to be supposed that this list includes all the covered reservoirs in this country, but it probably includes the most notable ones, both in size and design of roof. Many additions may be expected in the near future.

The material thus far used for covering has been wood in eleven cases, if we include the six reservoirs at Pasadena; brick in five instances, including the combination of brick and tile at Waltham, Mass.; concrete in two, counting the concrete and expanded metal roof at Rockford; and unknown in one case, with the probabilities in favor of wood. Most of the wooden roofs have been flat, and most of the brick roofs have consisted of arches sprung from lintels supported in turn by arches, the whole resting on piers. Some of the small brick roofs have been domed, notably the ones at Waltham and Coshocton. Groined arches have been used in only one instance, for the concrete covering at Wellesley. The lightest masonry construction has been at Waltham and Rockford, the arch of the Waltham reservoir being 3 to 4 ins thick, except for a short distance near the springing line, where tile and brick are combined. At Rockford, the concrete arch is only 2 ins. thick at the crown, but it is reinforced with 12-in. ribs and horizontal tie rods. It should be added that the Waltham roof covers a central well surrounded by a reservoir which is covered in turn by brick arches, the latter serving to take up the thrust of the tile roof. The water surface covered by tiles at Waltham is about 1,400 sq. ft; the concrete arch at Rockford covers about 8,500 sq. ft. of rectangular outline; while the large flat timber roof at Pasadena has an area of 166,000 sq. ft. The relative costs per sq. ft. covered were as follows: Waltham, $1.38; Rockford, 23½ cts.; Pasadena, 4.36 cts. These comparisons of cost should be considered in connection with the local conditions in each case. Doubtless the side walls of both the Waltham and Rockford reservoirs proper were increased in cost because they were to be roofed over, whereas at Oakland the timber roof was added to the reservoir as it stood before, which would have been an impossibility with a masonry roof. The relative permanency of the several roofs must also be taken into account, and the cost of their maintenance.

While English engineers and municipal officials have been experimenting, or waiting for others to do so, with new processes of sewage treatment, Paris has steadily gone on with its scheme for applying the sewage of the whole city to sewage farms. The work of diverting the sewage from the Seine, and at the same time of abolishing all privy vaults and cesspools, is so far completed that ceremonies in honor of the event were held on July 9. According to a review of the work given elsewhere in this issue the city now owns or controls over 12,000 acres of land devoted to sewage treatment. The order under which the immense outlet sewers, pumping stations and sewage farms have been executed provided that no more than 40,000 cu. m. of sewage per hectare per annum, or 11,700 gallons per acre daily, should be applied to the land. With the lavish use and waste of water prevailing in most American cities 100 gallons of sewage per capita is at present a low figure. This would mean, on the Paris basis, one acre of land to each 117 of population, or say 850 acres per 100,000 people. Some European sewage farms are much larger than this in proportion to population.

The sanitary possibilities from properly operated sewage farms, with first-class material, are unquestionable. The examples of Paris and Berlin, the latter city having far larger farms than Paris, would seem to warrant the adoption of the same means of sewage disposal by the largest American cities; but few of our smaller cities, even, have had the temerity to try sewage farming, and generally those approaching it most nearly have raised crops on filter beds rather than really practiced broad irrigation. Our engineers and municipal authorities are staggered with the idea of thousands of acres and hundreds of men devoted to sewage farming, while the thought of marketing the produce is overwhelming. All this is due to a variety of political and other conditions peculiar to this country too well known to need discussion.

Paris did well, in the light of recent years, to shun chemical precipitation, and far be it from us to predict that its sewage farms will not prove successful for years to come. It has not gone into the matter blindly, having had years of experience with sewage-irrigated crops at Gennevilliers. Its long outlet sewers and the repeated pumping to which the sewage is subjected doubtless play an important part in breaking down the solid matter in the sewage, both by bacterial and mechanical action. If scarcity of land in the future, or the development of the so-called bacterial processes, renders a change in the mode of treatment desirable it can readily be effected. Irrigation areas may be turned into beds for ordinary intermittent filtration, or prepared for some of the more rapid methods of filtration if they prove successful. Yet we much doubt whether large American cities will follow the example of Paris. The trend of English and American thought is to reduce the land and labor required for sewage treatment to a minimum, and the indications now are that the greatest progress for the next few years will be along those lines.

THE PROPER SIZE FOR SEPTIC SEWAGE TANKS.

The relatively small size of the septic tank at Champaign, Ill., described by Professor Talbot elsewhere in this issue, suggests the question, what is the proper ratio between tank volume and average daily sewage flow? The Champaign tank has a capacity of only 22,200 gallons for a dry weather flow which is already 300,000 gallons a day. This volume is liable to be increased "several times" whenever wet weather raises the ground water level, the sewers being on the separate system. With the normal daily flow of 300,000 gallons, the tank is filled 13½ times each 24 hours, or once in 106 minutes, while the mere doubling of the flow reduced the time of passage through the tank to 53 minutes, making no allowances in any of the cases for accumulations of sludge. In marked contrast with this is the English practice of providing a tank capacity equal to 24 hours' dry weather flow, which is occasionally reduced to some eight hours by the admission of limited quantities of storm water. Whatever differences may exist between the composition of English and American sewage, and between ground and storm water as the respective diluents, they go only a little way in explaining why the English tanks should be a dozen times as large, relatively, as the one at Champaign. Either the first are too large or the latter too small, providing they are seeking the same ends. The chemical results at Champaign, reported by Prof. Talbot, seem to indicate that the tank there has been doing remarkably good work, and that while it might be made larger with advantage, it need be nothing like the relative size of the tank at Exeter, England. The dissimilarity of local conditions and of available analytical data for the two places render any but the most general comparison of results of doubtful value. It appears, however, that the Champaign tank, when the samples were taken, was sending out an effluent very low in suspended organic matter, but otherwise not up to the English standard. The sludge in the Champaign tank seems to accumulate pretty rapidly, but with so small a tank that cannot be avoided, unless the sludge is practically nothing. It seems, too, as if the effluent was more like that from a poorly working filter bed than what would be expected from a properly working septic tank. The results as a whole suggest rather too much aerobic and too little anaerobic action, too much nitrification and too little putrefaction for a septic tank, which would partly account for the large amount of sludge for removal from the tank. These comments should not be considered as reflections on the Champaign tank, but as bearing on septic tanks in general.

Leaving now specific plants and results, some of the general principles bearing on the size of septic tanks may be considered. The object of these tanks is to remove the largest possible proportion of organic matter, more especially that in suspension, some being deposited in the tank and the balance being changed to forms more readily acted on by bacteria and oxygen. Theoretically the sludge would contain no organic matter, all of it being carried away by the tank effluent in a dissolved or finely-divided state, or escaping into the atmosphere in gaseous form. Practically, some organic matter will remain with the mineral substances and water making up the sludge deposit. Now, so far as the suspended matter is concerned, only time enough is required for sedimentation, since, theoretically, it remains in the tank, subject to bacterial action, until the organic matter disappears, leaving only mineral residue, in a finely divided state.

For removal of suspended matters alone it is very doubtful whether the results obtained after four hours' sedimentation are worth the extra expense for tank capacity, or could not be better attained in some other manner. This is more than double the time the dry weather flow at Champaign remains in the tank, but is only one-sixth, or less, the time allowed in England. What is the happy mean? It appears to be a decided disadvantage to allow the anaerobic bacteria to work on the sewage proper longer than is required to break down the organic matter, for if the putrefactive process is carried too far, the changes effected will be inimical to the aerobic bacteria which are to complete the work.

Since the suspended organic matter is supposed to remain in the tank until it has all been transformed by the anaerobic bacteria, and the resulting products are readily nitrified by the aerobic bacteria as soon as the effluent leaves the tank, can it be profitable to build septic tanks larger than is required for sedimentation? Possibly a longer stay, and the consequent diminution in current, would carry out less of the finely divided suspended matter said to be constantly rising and falling in the tank, gas bubbles lifting particles of sludge and gravity carrying them down again; but this action may be more advantageous than otherwise, on the supposition that the balance of the process of transforming this, as well as the more liquid portions of the sewage, can be carried on better outside than within the tank. Certainly the aim should be to maintain as uniform a flow as possible, in order that the deposit be not stirred up and washed out, upsetting the bacterial equilibrium both within and without the tank, and possibly clogging filter beds, where such are employed.

It has always seemed to us doubtful whether this system would prove to be generally practicable if tanks holding anything like 24 hours' flow were necessary. The evidence in hand indicates that some other method would be more economical in the majority of cases, unless the tank capacity can be kept down to four to six hours' dry weather flow. To send storm water through such tanks seems questionable in any case. Accessions of ground water reach the sewers more slowly and are quite different from storm water in character, having already been subjected to filtration. But they, too, may interfere with the smooth working of the process.

Before concluding, let us compare the septic tank, briefly, with other methods of sewage treatment, taking also a general glance over the whole field of sewage purification. Our present knowledge of the septic tank indicates that, like chemical precipitation, it is only a partial process, useful chiefly for the removal of suspended matter. Apparently it will remove rather more organic matter than will chemical precipitation, and it has the further advantages that it requires absolutely no chemicals, practically no labor, goes far towards doing away with the sludge problem, and turns out an effluent much more suitable for disposal by dilution, or for further treatment on land or otherwise, than that coming from chemical precipitation works. These good points regarding the septic tank should not blind anyone to the fact that the anaerobic bacteria may be brought into service by the proper manipulation of filter beds, possibly with the production of even less sludge, while for a high degree of purification resort must still be had to broad irrigation or intermittent filtration. Where plenty of suitable land is available these last-named processes alone can be so conducted as to eliminate the sludge problem, and raise sewage to the chemical and bacterial purity of drinking water. Perhaps they will not do it so cheaply, acting alone, as in conjunction with some of the new processes, but that they can do it, and that they have prior claim to the title of bacterial processes, there is ample evidence to show. The most significant feature of the new work in the bacterial treatment of sewage is based on the principle that several classes of bacteria are requisite for the most speedy and thorough results, and that each class works with far greater efficiency by itself than with others; therefore, the aim is to divide the process into as many stages as there are classes of bacteria, so that each may have the field to itself, and have its waste products removed for the action of the next class, instead of remaining to hinder the first. Most of the new processes, or adaptations of old ones, are content with differentiating the anaerobic and aerobic bacteria, as in the combination of septic tank and filter beds, or of coarse and fine filter beds, but one of them does not stop short of nine superimposed filter beds, or trays, surmounted by automatic tipping tanks. Such refinements tend to more than offset any saving in operating expenses by capital charges.

The information most needed now, regarding these new schemes of sewage treatment, is more extended analytical data from plants on a fairly large working basis, and reliable figures of cost of construction and operation, the latter extending over several years of every-day work. Chemical precipitation has been tried and found wanting; that is, it is only a partial process, and very expensive at that. Land treatment, whether by intermittent filtration or broad irrigation, effects the fullest possible purification, subject only to absence of suitable soil; but generally it, also, is so expensive as to be a grievous burden. What is desired is not a process capable of giving better sanitary results than land treatment at its best, but something cheaper and more generally applicable. It must be remembered, too, that a high degree of initial purification is not always necessary, for often a lightening of the burden thrown onto our streams is sufficient. There is a tendency to leave all or nothing to nature; to pollute water most shamefully until it can be borne no longer, and then to insist on an effluent better than the water into which it is turned. Earlier action and more moderate aims would often be far wiser. It is a very significant fact that in all the discussion of this matter in England during the last five years the only question regarding the bacterial contents of sewage effluents has related to the number and character of the bacteria engaged in the work of purification, whereas in America the percentage of bacteria removed is often taken into consideration. This indicates that our English cousins are not trying to turn their sewage into drinking water, while we have been regarding such a result as at least desirable. It also emphasizes the deplorable fact that we have let stream pollution go so far, and neglected water purification to such an extent, that it sometimes seems quite necessary to use drinking water standards for sewage effluents.

LETTERS TO THE EDITOR.

A Tile Roof Without Sheathing.

Sir: In the article on our tile roofing, in your issue of Aug. 3, there is one little error which is of considerable importance. On the first line under Fig. 2 you have the word "outside," which should have been "inside." This changes the meaning of the principle which we try to illustrate in there being no drip from the tiles.

Yours very truly, Ludowici Roofing Tile Co.,
Chicago, Ill., Aug. 7, 1899. T. D. Whitney, Secy.

[The article was submitted to the company for correction, and the mistake, which is too evident to be of much importance, evidently escaped its notice as it did our own.—Ed.]

The Protection of Structures from Lightning.

Sir: In connection with your article in the issue of Engineering News of Aug. 10, upon "The Protection of Structures from Lightning," some information as to ground connections may be useful. I try, always, to give the rod a surface of contact with the earth at least 1,000 times greater than the area of the outside surface of the rod for an inch of its length. This is to provide for the possibility of the ground becoming very dry, dry earth being a very poor conductor. I am constructing a building now where the columns project through the roof for ventilating and inspection purposes, and propose to have copper or plated points to the caps.

Where iron pipe is used, I think allowance can be made for the interior surface as a conductor. Water mains make a good ground connection.

Yours truly,
Howard Constable.

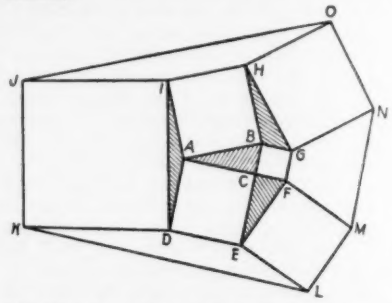
22 East 16th St., New York, Aug. 10, 1899.

A Geometrical Curiosity.

Sir: It may be of interest to some of the readers of the Engineering News to learn the following facts, which I have taken from one of my old note books, and which, with the exception of the first, I have never seen in print:

Take the right-angle triangle A B C, erect a square upon each of its sides, and then connect the outward angles of these squares with straight lines H G, F E and I D. Upon each of these lines describe the squares H N, F L and D J, and connect the outward angles of these squares with straight lines K L, J O and M N; we shall have the following facts:

1. The square of the hypothenuse A B is equal to the sum of the squares of the two opposite sides A C and C B (Euclid).



2. The three triangles A I D, B H G and C F E are each equal in area to the primary triangle A B C.
3. The lines connecting the outward angles of the external squares are parallel to the side of the squares opposite and equal to four times their lengths.
4. The three trapezoids D L, F N and J H are equal in area to one another, and each equal to five times the area of the triangle A B C.
5. The area of the two squares I K and H N are together equal to five times the area of the square I B or F L.

I will not take up your valuable space to demonstrate these facts. John Waterhouse.

1302 Empire Building, New York, July 27, 1899.

Progress on the New Dam at Holyoke, Mass.

Sir: I revisited the Holyoke dam last week. The construction of the work is going on very smoothly, the present contractor being Mr. Arthur McMullen, of New York city. They have practically all of the foundation built, so that they will have no further trouble with water, and the crest is finished for a considerable distance at one end, so that there is no question but that the dam will be completed early in the season next year.

Mr. McMullen is using the cableway scarcely at all. On account of the vibration it is impossible to lay stone with it, and when used for a conveyor, it interferes with the derrick booms. The sandstone for the rubble work is quarried about 500 ft. below the dam and is hauled to the dam by means of a narrow-gage railway, which, when it reaches the dam, runs parallel to it and just below it. The granite is unloaded from railroad flat-cars and also carried to place by the narrow-gage road. Derricks with long booms of Washington fir take the stone from the cars and place it in the dam.

The contractor has recently started a mixing machine for making his mortar which seems to be doing the work very satisfactorily and at a considerable saving in cost of labor.

There is at present a head of about 12 ft. of water the entire length of the dam, and it is absolutely water-tight.

The courses of the face are all lined and levelled by instruments, and the dam presents an example of very fine engineering work throughout.

Yours very truly,
Sanford E. Thompson, M. Am. Soc. C. E.
Newton Highlands, Mass., Aug. 9, 1899.

[A full illustrated description of this structure, prepared by Mr. Thompson, appeared in Engineering News for May 13, 1897.—Ed.]

Joints in Timber Roof Trusses.

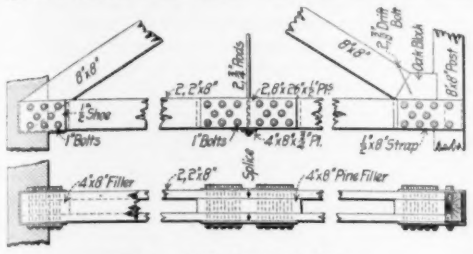
Sir: In your issue of Aug. 3, I noticed a peculiar framing for the joints of a timber roof truss, as designed by Mr. Gunwald Aus, M. Am. Soc. C. E., and in his explanatory note the writer expresses a desire to have any weaknesses in his details pointed out. As I have recently had to design some timber roof trusses for the same reason as given by Mr. Aus, the high price of steel, I examined, with interest, the details as given, and find the joints, as framed, will not give the maximum strength of the members.

Allowing unit stresses of 1,300 lbs. for tension, 1,100 lbs. for compression and 130 lbs. for shear parallel to the fiber, the maximum strength of two 2 × 8-in. timbers in tension is 41,600 lbs. In the end wall joint, as designed, the developed strength, disregarding friction, is that due to the compression of the fibers of the main members by the oak block and the transverse bolts, which are presumably ⅝-in. These bolts, together with the oak block, which

is mortised for ½-in. into the main member, must take up the tensile strain and will give the following strength: $[3 \times \frac{5}{8} \times 2 + 3 \times \frac{1}{8} \times 1\frac{1}{2} + \frac{1}{2} \times 8] \times 2 \times 1{,}100 = 17{,}500$ lbs. The strength of the reduced area of the members themselves being $[1\frac{1}{2} \times 8 \times 2 - \frac{5}{8} \times 3 \times 2 \times 2] \times 1{,}300 = 25{,}350$ lbs. By increasing the size of the bolts a strength somewhere between these two results could be obtained.

A similar analysis of the central splice and post end-joint shows a maximum strength of 17,500 lbs. and 24,550 lbs. The post end-joint also has not sufficient bearing on the post to make a strong joint. The above values show that the weaker joints develop only ⅝ of the total strength of the tension members, which is too low a proportion for good practice.

The enclosed sketch, in which I have followed Mr. Aus's general design, shows joints which are as simple and



Details of Timber Roof Truss.
Designed by W. W. Brush, C. E.

easily made as those given by Mr. Aus and develop a much greater strength. For any joint as given, the net area of the tension members is reduced by the two 1-in. bolts by 8 sq. ins., leaving the available net area of 24 sq. ins. to withstand the strain, or an available strength of $24 \times 1{,}300 = 31{,}200$ lbs. The bearing strength of the eight 1-in. bolts is greater, being 35,000 lbs. This form of joint gives as an available strength of the tension member ¾ of the total strength, or double that given by Mr. Aus's details. The changes in the framing in the end-joints give stronger joints than those given originally.

Yours truly,

W. W. Brush, C. E.

427 Nostrand Ave., Brooklyn, N. Y., Aug. 7, 1899.

Arsenic as a Preventative of Yellow Fever.

Sir: The following clipping from the "Brazil-Medico," of Rio Janeiro, will be of great interest and benefit to American engineers about to sail for ports infected with yellow fever:

ARSENIOUS ACID AS A PREVENTIVE OF YELLOW FEVER.

Dr. J. P. de Rego Cesar noticed that non-acclimated persons in Brazil, who had occasion to take arsenic for any reason, were not molested by yellow fever, and he commenced to administer it as a preventive, with most satisfactory results, confirmed by the experience of other local practitioners. Dr. Rocha reports, in this article, the results of daily prophylactic doses of half a milligram of arsenious acid administered during the summer season to the entire force of a certain factory, over 200 men, for the last five years. The men are frequently changing, are most unacclimated, live in unhygienic surroundings, and infected localities, and take no precautions against contracting the disease. During the terrible epidemic of 1894, three of them were attacked, but soon recovered; exceptionally light cases among the prevailing mortality. In the epidemic of 1896, twenty men contracted the fever a few days after their admission to the factory, each having received only a few doses of the arsenic. But the effects were evident in the benignity of the cases, all dismissed from the hospital in from four to six days, while a couple of extra hands only rarely employed, and thus not receiving the arsenic regularly, succumbed to the disease. There have been no cases in the factory since 1896, although yellow fever has scourged the city again and again, and formerly ravaged the factory. Another group of 150 men to whom the prophylactic doses were regularly administered have also escaped without a single case. Persons just arrived are advised to repeat the dose three times a day the first week, twice a day the second, and thereafter once a day. No one thus treated has contracted the disease to date. Civil Engineer.

My brother, P. H. Ashmead, on his way to Ecuador with the construction force of the Guayaquil & Quito R. R., will pass through two infected ports, Panama and Guayaquil. I have furnished him with 100 ½-milligram (1-128-grain) pills of arsenious acid, and advised him to take one pill three times a day, for three days, before reaching an infected port, and for five days (the period of incubation of yellow fever) after leaving such port. (Precaution: Should the eyelids become much puffed or the stomach deranged, after the use of arsenic for a week or two, of course its use must be stopped, until these symptoms disappear.)

Respectfully,

Albert S. Ashmead, M. D.

65 W. 12th St., New York, Aug. 6, 1899.

The Preservation of Railway Ties.

Sir: Your article on wood preservation is timely. Having had considerable experience in that line, I feel very much interested. Your article is largely confined to three processes, viz.: Burnettizing, creosoting and the tannin or Wellhouse process. All of them are good and will answer the purpose for most work, except railway work. The copper and barium or zinc and barium processes are best adapted to railway work. The vulcanizing process is very faulty. As to the cost of a plant, I could build a portable plant for railway work that would cost a very small amount compared with the results that would be obtained. I have reference to treating ties while lying in the roadbed or banked beside the track. I could treat them in lots of from 50 to 100 at an average cost of about 2 cts. per cu. ft. The treatment would be zinc sulphate and barium chloride, using ½ lb. of each per cubic foot of wood treated. This combination forms barium sulphate, which is insoluble in water or acid, and gives the timber an increased crushing strength. The zinc having a great affinity for iron, the spikes hold more firmly. The many processes in use are more or less objectionable for railway work. Kyanizing or the corrosive sublimate process is expensive and very injurious to workmen.

Creosote is a good preservative, but when it is used the wood will not hold the spikes. The Wellhouse or tannin process, in my opinion, is undesirable, as it is not a good thing to seal up in the wood the fermenting substances that are the cause of decay.

Vulcanizing destroys the strength of the wood, causing it to split very easily when the spikes are driven on each side of the rail. Sulphate of copper and barium are too expensive. Zinc and barium are very much cheaper and are just as effective. A portable plant could be placed upon cars and a hundred ties could be treated at once very successfully while lying in the roadbed. This may seem impossible, but it is, nevertheless, true. A model plant for treating one at a time could be constructed at a cost not exceeding five dollars.

I constructed for the Government at the Charleston Navy Yard a plant costing $40,000. The vulcanizing plant at New York was copied from this. I also constructed a zinc and barium plant at Greenpoint for Mr. J. Lorillard. Having made the different classes of wood a study, I am firmly of the opinion that the cheaper woods can be made to do as good service for railway ties as the best oak. I have experimented with such woods as beech, white wood, black oak, juniper and spruce. After five years in the roadbed at the Euclid Ave. crossing of the Cleveland & Pittsburg R. R., they were still in a good state of preservation. The first cost of a treating plant is the great objection urged by the railway companies. I am of the opinion that they will soon be compelled to look at the question in a different light, and to cast about for a process of some kind. Respectfully yours,

18 Chestnut St., Cleveland, Ohio. E. Martin.

Kutter's and Darcy's Formulas for Flow in Pipes.

Sir: Referring to Mr. J. L. Campbell's communication under the above title in your issue of August 10, I think that the more general accuracy claimed for Kutter's formula lies in the fact that after the actual discharge through a certain pipe has been experimentally ascertained a numerical value can be deduced for the variable coefficient n, which will cause the formula to yield the correct result for that particular pipe.

Its true function seems, therefore, to be the deduction from a number of experiments of a series of values for the coefficient n, which shall represent the variations of flow caused by variations in the character of the pipe or of the conditions under which it is working. Practically, it leaves the engineer who desires to calculate the proper diameters for his water mains entangled in a labyrinth of coefficients, with the added disadvantage that if anything goes wrong he must bear the blame. The formula is always right, and the coefficient is also all right, as long as it is confined to its abstract expression "n." The trouble occurs when the engineer is obliged to assign a numerical value to it which may not, and probably will not, be justified by the results.

Darcy seems to have fully recognized the fact that for practical purposes, in dealing with commercial cast-iron water pipe, it is useless to vary the coefficient through an endless gamut of "rough," "pretty rough," "not quite so rough," etc., etc., and he struck at once for a superior and inferior limit, which he designated simply as "rough" and "smooth," and which vary as 1 is to 2. His equation, solved for quantity of discharge, gives that for smooth pipes as 40% greater than for rough. Solved for diameter, it gives the equivalent diameter for a rough pipe as 15% greater than for a smooth one.

These seem very elastic limits, but I believe that practically they are the very best that anticipatory arithmetic can do for us. A pipe line as actually laid is a very coarse piece of apparatus, and all refinement of calculation is repugnant to its nature. As far as my observation goes, the actual discharge through cast-iron pipe lines always lies between Darcy's two extremes of rough and smooth, and all we can do in prophesying the probable discharge through our mains is to say that it will lie between these two extremes probably, in the case of a new and well-laid system nearer to the higher than the lower limit. If we want to come closer than that, the remedy will lie in using a different kind of pipe, and not a different formula. Darcy's formula is exactly as good as the pipe line of commerce, and any further improvement must be sought for at the mechanical rather than the mathematical end.

As regards the comparison between riveted and cast-iron pipe, we are still somewhat in the dark as to the average discharging capacity of the former. There appear to be several varieties of sheet iron and steel pipe, and the variations must affect the flow in different degrees. The capacity of the riveted lapped pipe when new and clean is probably intermediate between that of smooth and rough cast-iron, with a leaning towards the lower limit. There must be some uncertainty in the case of lapped pipe, particularly in the smaller diameters, in exactly determining the true equivalent diameter.

Yonkers, N. Y., Aug. 11, 1899. E. Sherman Gould.

THE PRESENT CONDITION OF SEWAGE DISPOSAL AT PARIS.

On July 8, 1899, the new works executed for diverting the sewage of Paris from the River Seine were officially inaugurated in the presence of the Ministers of Public Works and of Agriculture. The general purpose of the work accomplished is to convey all sewage water from the city to areas set aside remote from the city, and to purify this water by broad irrigation before returning it to the river.

In its issue of July 22, "Le Genie Civil" reviews the work done since 1895, and generally illustrates the system adopted, and while the details have been published in our issues of Nov. 8, 1894, Aug. 22, 1895, and July 9, 1896, it will be interesting to briefly outline the progress made in this enormous undertaking.

Under the Engineer Belgrand, and previous to 1895, a system of sewers and intercepting sewers was devised, diverting all the sewage from the Seine and collecting it in three great basins, each drained by a special collector. The North collector, so-called, led to the river, at Saint Denis, all the waters of the North Basin, covering an area of 3,206 acres; the Asnieres collector reached the Seine opposite the place of that name, and drained the Central Basin of 5,599 acres; and the Marceau collector drained the South Basin, of 7,679 acres, and crossing the Seine by a syphon, near the Alma bridge, it emptied into the Asnieres collector, near the point where this collector reaches the river. These two last-named collectors were later found to be insufficient for the volume to be handled, and the Clinchy collector was located parallel to them and completed in 1898.

While these works satisfactorily ensured the health of Paris by discharging all sewage into the Seine below the city, this result was accomplished at the expense of the down-river communities. The law of July 10, 1894, making obligatory the discharge of all household drainage into the sewers, increased the danger to the general community, and it was at once apparent that some method must be devised for rendering the sewage harmless before it was finally discharged into the river. Numerous experiments in the treatment of sewage had been made at Clinchy in 1868, and later, on a large scale, in the sewage farms at Gennevilliers. The law of April 4, 1889, recognized in a definite manner, the purification of sewage by broad irrigation, in ceding to the city of Paris, for this purpose, a new area of 1,976 acres at Acheres; and in 1896, the total area of irrigable land at Gennevilliers and Acheres was about 4,686 acres. The farms at Gennevilliers were fed by a branch from the North collector, crossing the Seine on the Saint-Ouen bridge; and also by a part of the sewage passing through the Marceau and Asnieres collectors and lifted about 33 ft. by a system of pumps at Clichy. This same pumping plant also raised the sewage intended for Acheres into a masonry conduit leading toward that farm.

The pumping plant at Clichy included four groups of motors and pumps, each having a capacity of 406 gallons per second towards Acheres and 234 gallons per second towards Gennevilliers. The Acheres aqueduct, as it is called, serves as a general outlet for all the sewage water of Paris except that collected in the North Basin. By this aqueduct the sewage passes to the plant at Colombes, where it is again lifted by four groups of pumps, each having a capacity of 130 gallons per second. The sewage here crosses the Seine and reaches the top of the hill of Argenteuil, and is thence distributed over the Acheres farm by a main conduit which is 9.3 miles in total length.

counting from the Clichy pumps; it again crosses the Seine by a sypnon, opposite Herblay, to reach the Acheres farms.

The total area of 1,900 hectares, or 4,686 acres, at Gennevilliers and Acheres, permits the annual treatment of 76,000,000 cu. m. of sewage, on the basis of 40,000 cu. m. to each hectare per year, or about 11,700 gallons per acre per day. But as the total annual volume of Paris sewage is about 180,000,000 cu. m. (some 130,000,000 gallons a day), about 2,600 hectares, or 6,500 acres, of land were still required for complete treatment. The city of Paris found the additional land required at Mery-Pierrelaye, Carrieres-Sous-Poissy, Mureaux, etc.; the work necessary for this extension was authorized by the law of July 10, 1894, and the cost was estimated at about 30,000,000 francs. The work recently completed includes the farm of 5,310 acres at Mery-Pierrelaye, and the farm of 2,345 acres at Carrieres-Trill, and by these the total of available irrigable land is now raised to about 12,340 acres, or an area equal to the treatment of all the sewage of Paris on the basis given above.

The work done in 1895-99 can be briefly summed up as follows: Commencing at Herblay, the main conduit has been lengthened about eight miles. One branch from this conduit leads to the farm at Pierrelaye, and another, after crossing the River Oise by a syphon, leads the sewage to the Triel farm. The elevating plants at Clichy and at Colombes have been also reinforced, and the latter now is capable of lifting 1,768 gallons per second 131 ft. high.

At these new farms the irrigation is carried on exactly as at Gennevilliers and Acheres; and of the 5,310 acres at Mery-Pierrelaye 4,500 acres are now available for irrigation. On all parts of the area low enough the sewage is delivered by gravitation, and the higher portions are fed by the pumping plant on the farm, with three distinct zones of distribution controlled by gates on the pipes. Of the 2,345 acres in the sewage farm at Triel only 250 actually belong to the city of Paris, though the city controls the remainder. The engineers in charge were Messrs. Bechmann and Launay, Chief Engineers for the Sanitation of Paris. Maps showing the territory occupied by the old and new farms were given in our issue of Aug. 22, 1895.

PORTABLE PLANT FOR THE PRESERVATIVE TREATMENT OF RAILWAY TIES.

While the advantages of using ties which have been subjected to an efficient preservative treatment are pretty generally recognized in the abstract, American railways have been, on the whole, very slow to avail themselves of these advantages, which lie not only in the actual financial economy in the ties but in the economy and greater efficiency of track work due to their prolonged life and the consequent decrease in general disturbance of the track. This backwardness has been presented very plainly in abstracts of papers by Mr. W. W. Curtis and Mr. S. M. Rowe in our issues of June 29 and July 20, 1899. One reason for this same backwardness has been the abundance and cheapness of timber which has prevailed until recent years, and another has been the objection to the cost of installing a plant or the delay and trouble incident to having ties sent to a treating plant. The cost and the difficulty of obtaining really good timber for ties are now greatly reducing the force of arguments based upon the first objection. As to the other objection, Mr. Octave Chanute, M. Am. Soc. C. E., President of the Chicago Tie-Preserving Co., is endeavoring to overcome them by the introduction of a portable plant for treating ties, which may be hauled to any desired point and set up for operation on temporary sidetracks. The plant may be moved with economy to any point where not less than 100,000 ties are to be treated. In general the plant resembles that in use on the Southern Pacific Ry., which was described in our issue of April 4, 1895. It has been built upon the same patents, those of Mr. W. G. Curtis and Mr. J. D. Isaacs, of the Southern Pacific Ry., but with some modifications and improvements, especially in the means for ascertaining specifically the amount of preservative used. These improvements have been introduced by Mr. Chanute, who has made a study of timber preservation for the past fourteen years.

The plant consists of a horizontal cylindrical retort, 8 vertical cylindrical iron tanks (4 for the zinc-chloride solution and 4 for the gelatine solution), 4 vertical cylindrical wooden tanks for the tannin solution, a rectangular vat for storing the zinc-chloride, a similar vat for mixing, and an equipment of boilers, pumps, piping connections, with a bolted flange joint at the middle. This enables it to be separated for transportation, each 58½-ft. section being mounted on a pair of diamond trucks. Each end is fitted with a heavy hinged door, secured by bolts in the slotted flanges of the door and cylinder. At the lower or loading end of the retort is a drainage well, and at the opposite end is a sheave for the wire cable by which the trains of cars or "buggies" are handled. A track of 2 ft. gage is laid in the retort and connects with the outside tracks. A special feature of the track arrangement is that each buggy passes over a 6-ton scale on its way to the retort, the number of the buggy and the weight being recorded. On coming out with the treated ties the buggies are again weighed in the same manner. The dead load of each buggy is known, and this being subtracted shows the difference in weight of each load of 40 ties. Any load that does not show a sufficient increase is switched out and treated over again. This insures greater uniformity and a more thorough treatment than if these comparisons were made for the total number of ties for each charge instead of for each buggy load. The cylinder holds about 14 buggy loads, or 560 ties, as an ordinary charge.

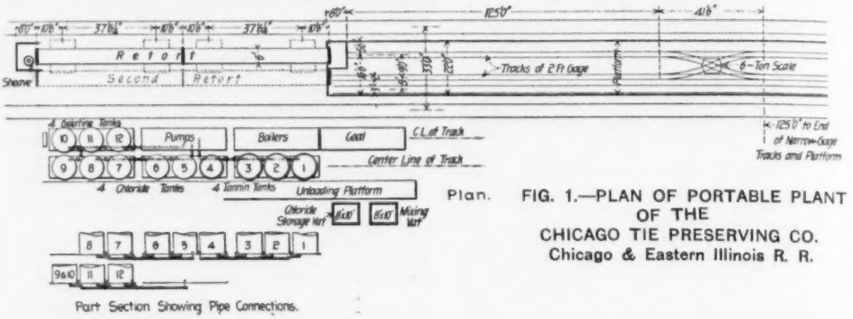


FIG. 1.—PLAN OF PORTABLE PLANT OF THE CHICAGO TIE PRESERVING CO. Chicago & Eastern Illinois R. R.

The cars, with the pumps, boilers, coal, tanks, etc., are arranged on two tracks, side by side, with a storage platform 22 × 320 ft. at one end of the retort. This platform is level with the car floors and the temporary platform for receiving the supplies. This arrangement greatly facilitates the handling of material and the preparation of the solutions.

Fig. 2 is a rear view of the plant, with the retort on the left and the tanks, pumps and boilers on the right. The retort is on its trucks, which are blocked, but it will be noted that the tanks are supported on a platform. This is a temporary arrangement until the cars are built for them. Fig. 3 shows the boiler and pump plants on their cars before the temporary housing was erected.

After the charge is in place and the doors are closed the air is exhausted by an air-pump, and steam at 20 lbs. pressure is then admitted for

FIG. 2.—VIEW OF PORTABLE PLANT FOR TREATING TIES.

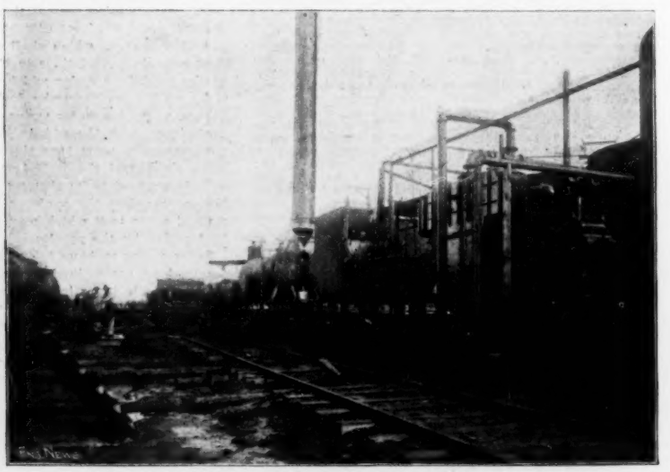


FIG. 3.—VIEW OF BOILER AND PUMP EQUIPME NT OF PORTABLE PLANT FOR TREATING TIES.

etc. For transportation the plant forms a train of ten or more cars, two for retort, four for the 12 tanks, one each for the pumps and boilers, and two for the 45 buggies and for the two vats. Fig. 1 shows the plant as now in place at Mt. Vernon, Ill., where it is working on a contract for the Chicago & Eastern Illinois R. R.

The retort is 6 ft. diameter and 117 ft. long,

three hours, the temperature within the cylinder not being allowed to exceed 260° F. A vacuum is again created to cause the sap to flow out of the ties, and this is maintained for one hour, when the liquid is drawn off. The cylinder is then filled with zinc-chloride solution, having a strength of 3% to 4%, and this is retained under a pressure of 100 lbs. for two hours or more, when the cylinder is again emptied. It then receives its charge of the gelatine solution, and then the third charge of the tannin solution, all under the same pressure and for one hour. By applying the solutions separately a much greater penetration and absorption are insured, the zinc-chloride solution (which is the preservative) being very fluid, while the other solutions (which are merely to close the sap cells and retain the preservative within the wood) are thick and ropy and penetrate but a short distance. Careful measurements are made of the quantity of each solution which enters and is drained from the retort, and the weight of the timber on each buggy is carefully ascertained by actual weighing and estimating from specially prepared tables. As a result of the careful treatment and careful records of the various stages of the process it is found that a much greater quantity of preservative is forced into each tie than was the case under former conditions.

The ties now being treated are of water-oak, red-oak and yellow or black oak. The former timber has a life of only about four years when used without treatment, but a life of 12 to 15 years is confidently expected for the treated ties. Their cost is cheaper than that of untreated white oak. The ties are to be used for repairs and for the Marion extension of the Chicago & Eastern Illinois R. R., which is now under construction. As they are not needed directly they are being stacked and given time to dry and for the chemicals to become fixed. This should be done

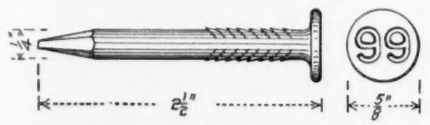


Fig. 4.—Galvanized Nail for Marking Treated Ties.

in every case, but some railways are in such a hurry that the ties coming wet from the retort are placed directly in the track. The full advantages of the preservative treatment cannot be expected under such conditions.

Another matter to which the company is giving careful attention is that of properly seasoning the ties before treatment. Hitherto ties have commonly been treated as soon as delivered at the works, but the company now requests that ties be cribbed up and marked with the date of inspection, and then when they are received they are, if necessary, stacked in the yards for some time before being treated.

The following table shows the record of a single run, and it will be noted that the weight of each buggy is given, the weight and number being marked on each, so that the actual weight of the load can be readily ascertained:

Record of First Run at Tie Preserving Plant, Mount Vernon, Ill., July 17, 1899.

Buggy, No.	Buggy, Weight, lbs.	No. of ties.	Weight—Treatment—Before, lbs.	Weight—Treatment—After, lbs.	Weight—Increase lbs.	Solution per tie, lbs.	Zinc-chl'ride solution, %.
25	880	44	6,700	8,045	1,345	30.6	3.7
20	870	42	6,180	7,245	1,065	25.3	3.7
21	857½	42	6,210	7,720	1,510	35.9	3.7
22	885	43	6,630	7,905	1,275	30.0	3.7
19	870	43	6,480	7,600	1,120	26.0	3.7
18	855	42	6,672½	7,615	942½	22.4	3.7
16	887½	42	6,640	7,980	1,340	31.9	3.7
15	885	39	6,305	7,735	1,430	36.6	3.7
45	872½	39	6,560	7,905	1,345	34.5	3.7
44	885	39	6,517½	7,670	1,152½	29.5	3.7
43	855	37	6,165	7,380	1,215	32.8	3.7
42	867½	40	6,720	7,740	1,020	25.5	3.7
41	855	42	6,875	8,270	1,395	33.2	3.7
40	870	41	6,385	7,790	1,405	34.2	3.7
	12,195	575	91,040	108,600	17,560	Av., 31.	
Weight of buggies.			12,195	12,195			
Weight of wood..			78,845	96,405			

78,845 ÷ 575 = 137 lbs. per tie before treatment.
96,405 ÷ 575 = 168 " " after treatment.
168 — 137 = 31 " " increased weight.
Cu. ft. of timber in charge (by gaging retort) 1,464
78,845 ÷ 1,464 = 58.8 lbs. per cu. ft. of timber.
96,405 ÷ 1,464 = 65.9 lbs. per cu. ft. of timber.

In preparing statistics and records of life and renewals of ties great difficulty has always been experienced in getting certain and accurate dates of the placing of the ties in the track. In many cases the memory of a roadmaster or section foreman is all the evidence obtainable. To obviate this difficulty in the future Mr. Chanute has each treated tie marked by means of a stamp hammer and also by a 2½-in. galvanized iron nail, Fig. 4, in whose head are stamped the last two figures of the year of treatment.

AN INSTRUMENT FOR INDICATING TEMPERATURES AT A DISTANCE.

It is frequently desirable, and sometimes necessary to obtain temperatures in distant or inaccessible places, such as the bottom of wells or lakes, or in the holds of vessels. Besides the requirement of reliability for an instrument to do this work, there is an equally important one of simplicity. We describe below an instrument which fulfils both requirements in a satisfactory manner. The instrument referred to, shown in Fig. 1, bears the name of the Thermophone, and is the joint invention of Messrs. George C Whipple*, and Henry E. Warren.

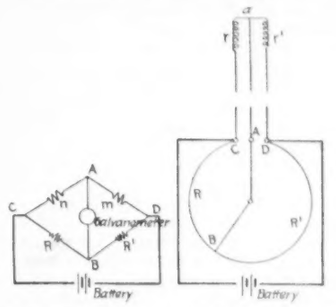
The Thermophone belongs to the resistance class of electrical measuring instruments, and depends upon the principle of the familiar Wheatstone Bridge. Consider the two conducting paths, C A D and C B D, Fig. 2. There must be a uniform and equal fall of potential over each. Now if a galvanometer has its two terminals connected to a point on each it will or will not show a deflection accordingly as the points selected have not or have the same potential. If they have the same potential evidently they divide the two paths into proportioned parts. That is, if the galvanometer, as shown in Fig. 2, gives no deflection, then n : m : : R : R¹. Bearing in mind what has been said, the right-hand sketch of Fig. 2 follows as a direct result. C, a, D remains the same, that is, instead of n and m we have the two resistance coils, r and r₁. C, B, D is a circular piece of bare german silver wire upon which a movable contact arm rests. By moving this arm any desired raito of the resistances R and R₁ can be obtained.

It is, of course, well known that the electrical resistance of metals varies with any change of

Fig. 1.—The Thermophone—An Instrument for Measuring Temperatures.
Messrs. George C. Whipple and Henry E. Warren, Inventors.

temperature, and generally two different metals are affected differently by the same change in temperature. Now if r and r₁ are made of different metals, but alike in other respects, and are connected by similar wires to C, A, D, it will be seen that for any given temperature, a definite relation exists between the resistances of the coils r and r₁. If the temperature of r and r₁ is varied ever so slightly, a different resistance ratio exists. However, in any case, the lever (B) can be moved until R and R₁ bear the same ratio, and the circuit is balanced.

Each ratio of (r) and (r₁), which may be selected so as to represent degrees or fractions of degrees, has a corresponding position of the lever (B).



Usual Wheatstone Bridge. Slide Wire Bridge as Constructed.

Fig. 2.—Diagrams Showing Principle of the Thermophone.

These various positions can be marked and the calibration of the instrument is then completed.

The theory upon which the instrument is based can be shown by referring to Fig. 2, in which C D represents the slide wire or variable resistance, whose length may be called L, and on which B is the point at which the telephone gives no sound; and r and r¹ are the resistance coils, made, for instance, of copper and german silver. Let C B = x; then D B = L — x. According to the theory of the Wheatstone bridge, assuming that the resistance of the heavy con-

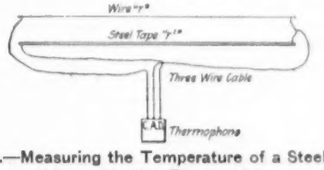


Fig. 3.—Measuring the Temperature of a Steel Tape Line with the Thermophone.

necting wires is negligible, the resistance of the copper coil, r, is to the resistance of the german silver coil, r₁, as x is to L — x, i. e.,

$$\frac{R\,(c)}{R\,(g-s)} = \frac{x}{L-x}.$$

If the resistance at 0° C. is called unity, the above formula may be applied to any temperature, t, by inserting the temperature coefficients for the two metals, i. e.,

$$\left\{\frac{R\,(c)}{R(g-s)}\right\}_t = \frac{1 + 0.003824\,t + 0.00000126\,t^2 + }{1 + 0.0004433\,t + 0.000000125\,t^2 + } = \frac{x}{L-x}.$$

Simplified this becomes

$$\frac{x}{L-x} = 1 + 0.0033807\,t - 0.000000391\,t^2 +.$$

There are but two unknown quantities, (t) and (x) in the equation, and if certain values are assumed for (t) we may calculate the corresponding values for (x). This admits of finding the theoretical position for B corresponding to any temperature of the coils, or if the position of B is given, we may find the corresponding temperature.

As an illustration, assume that the point B is at C, the extreme end of the bridge. In this case x = 0, and the corresponding value of t is found to be — 286° C, which is not far from the absolute zero. With B at D, the other end of the slide wire, t becomes infinite. Between these two points the line rspresenting the relation between temperature (t) and the distance C B will be the curve, whose equation is given by the above formula. The values of the temperature coefficients of copper and german silver given in the equation apply only between 0° and 100° C.

The resistance ratio changes about 1% for each 5° F., which is considerably above the rate of expansion of solids or liquids. Slight differences in resistance may be measured more easily and

*Mt. Prospect Laboratory, Brooklyn Water-Works, Brooklyn, N. Y.

with greater accuracy than small changes in length of volume. With a thermophone constructed for ordinary use with a range from — 15° to 115° F., temperatures may be read to 0.1°. With an instrument of less range, or with one of the same range but having a larger dial, the degrees are longer, and consequently a greater sensitiveness may be obtained. With a dial 8 ins. in diameter, readings may be taken to 0.01335° F.

The galvanometer of the Wheatstone Bridge is replaced in this instrument by a telephone receiver, in circuit with which is placed a vibrator resembling the vibrating armature and spring of an electric bell. This keeps up a continual humming, except when the balance is established, and then no sound is heard. The battery used is of the dry-cell type, and this, together with the vibrator slide, wire resistance and calibrated dial, is mounted inside the box. The telephone receiver is attached to the outside, while the resistances r and r1 are incased in a small brass tube which is straight or bent into a coil, or a ring, according to the use for which it is intended. This resistance is composed of long flat coils of insulated resistance wire which are bundled together and fitted into a small closed tube, which is afterwards filled with oil. This precaution is necessary to secure a prompt response to any temperature changes and complete protection from atmospheric corrosion and the rough handling which a portable instrument of any sort invariably receives.

In choosing the amount of the resistance to be used for the sensitive coils two opposing conditions present themselves. The resistance must be kept low enough to get sufficient sensitiveness when using an ordinary telephone, and it must be kept high enough to avoid error caused by the heating of the wires by the battery current and the resistance of the bad wires. In the instrument as at present manufactured a value of 100 ohms for each coil has been selected as best fulfilling the conditions for ordinary work. There is no difficulty, however, in using coils as low as 25 ohms or as high as 1,000 ohms. It may be added that the battery need be in circuit only while making a reading, thus eliminating the heating effect of the current. Usually it is desirable to make the resistance of the two coils such that they shall be equal at about the middle of the scale which the instrument is designed to read. For ordinary temperatures it is customary to make them equal at about 50° F.

The possibilities of the instrument are many, both in the region of practical utility and in connection with scientific or laboratory work. An example of the former is afforded by the system installed in one wing of the Capitol at Washington. Resistance coils are placed in different locations, with lead wires returning to a switchboard in the engine-room, where a thermophone is mounted. By means of a small switch the engineer can connect the instrument to any resistance coil and read directly the temperature of that room or locality. For the prevention of fire on ship board the instrument also has a field of usefulness. For this work resistance coils are placed in different parts

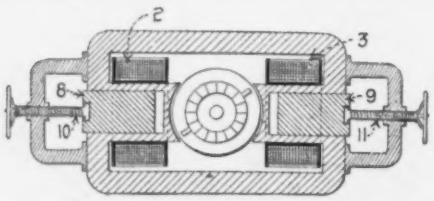


Fig. 2.—Diagram Showing Principle of Speed Control for Small Electric Motors.

of the hold and any increase in temperature can thereby be detected. In connection with manufacturing processes involving the maintenance of even temperatures, the instrument will prove of great service. As means of studying the temperatures of reservoirs, lakes or the ocean, the thermophone is especially well suited. Another use, indicated by Fig. 3, is the determining of the exact temperature of a steel tape line when it is used to measure base lines. Experiments in this direction have been made by Prof. A. E. Burton.

For this purpose the steel tape and a parallel wire act as the resistance coils, and as both are together throughout their length it will be seen that they are subjected to the same temperature changes.

For the material from which this description has been prepared we are indebted to Mr. G. C. Whipple, in charge of the Mt. Prospect Laboratory of the Brooklyn Water-Works, Brooklyn, N. Y.

A NEW FLEXIBLE SHAFT AND MULTI-SPEED ELECTRIC MOTOR COMBINATION.

We illustrate in the accompanying cuts a portable electric motor designed to drive a flexible shaft which is of particular interest for its compact construction and admirable system of speed regulation, giving, it is claimed, about 60% variation in speed without loss of efficiency. Fig. 1 is a view of the motor with the flexible shaft attached, and in position for operation, and Fig. 2 explains the principle of the speed regulating system, which is described by the inventor, Mr. Frederic A. Johnson, as follows:

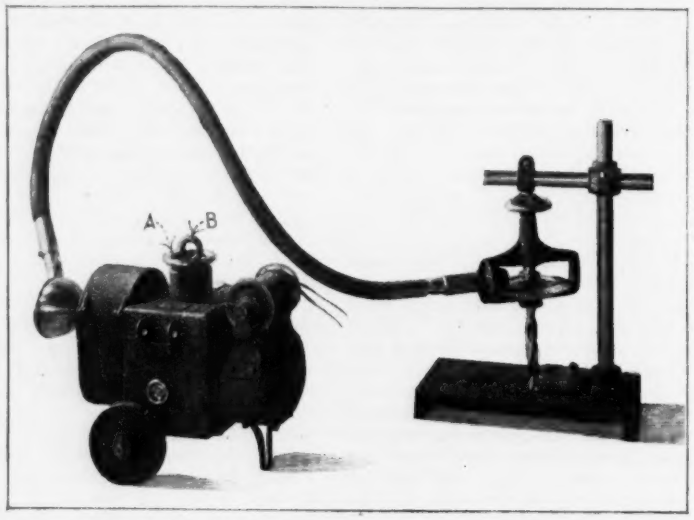


FIG. 1.—VIEW OF MULTI-SPEED ELECTRIC MOTOR OPERATING STOW FLEXIBLE SHAFT.
Frederic A. Johnson, Electrician; Stow Manufacturing Co., Binghamton, N. Y., Manufacturers.

The method shown by Fig. 2 is particularly adapted to small motors. The pole pieces are hollow and the cavities are fitted with soft iron masses 8, 9, whose positions may be adjusted by means of the screws 10, 11. When these masses are wholly or partially removed from the cavities, the total magnetic flux will be greatly decreased, thus raising the speed, while the magnetization of the pole-tips will still remain sufficiently strong for sparkless commutation.

Some tests have recently been made of a one-horse-power, inclosed, shunt motor designed for connection to the Stow flexible shaft, and which is shown in Fig. 1.

This machine was wound for 110 volts, the field current was 0.36 ampere. Its weight was about one-third less than that of the motor previously employed for a like purpose, having the same power, range of speed and general design, but whose speed was regulated by varying the field magnetism in the usual way.

On account of its small size, the method of speed control shown in Fig. 2 was used. The cast-iron pole-piece being made hollow, inclosing a wrought iron plunger which could be raised by turning the wheel A or by lifting the eye-bolt B.

It was found that an elevation of about 2½ ins. increased the speed from 830 to 1,170 revolutions per minute, and that the motor would run sparklessly, in either direction, under all loads up to 50% overload, and at all speeds between the above limits, without changing the position of the brushes. Furthermore, while the motor was running under full load, the plunger could be suddenly lifted to its full height, thus instantly raising the speed by almost one-half, and,although the ammeter needle would momentarily register about 23 amperes, no sparks were perceptible at the brushes. This machine has been running under the most severe conditions for a considerable length of time, and its behavior has been in every way extremely gratifying—in fact, it has exceeded the expectations of all interested.

Besides its accurate speed regulation, a great advantage claimed for this motor is its form, it having three flat sides for direct connection to tools or machinery. The motor is controlled by the Stow Manufacturing Co., of Binghamton, N. Y., to whom we are indebted for the information from which this description has been prepared.

WEATHER TABLE FOR JULY, 1899. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Degrees Fahrenheit.)				Wind.			Precipitation—Rain or melted snow. (Inches.)		
		Average.	Max.	Min.	Range.	Velocity in miles per hour. Average.	Max.	Direction at time of max. velocity.	Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	65.3	90	37	53	7.9	42	SW	3.41	0.71	18
	Portland, Me.	67.9	87	48	39	7.2	29	NW	3.92	2.38	12
	New York City.	73.8	90	59	31	12.7	50	NW	6.20	2.50	14
	Pittsburg, Pa.	75.6	95	55	40	4.4	20	SW	3.13	0.83	13
	Chicago, Ill.	72.2	90	59	31	12.3	37	NE	6.66	2.17	11
	Omaha, Neb.	75.0	92	58	34	6.4	27	N	1.73	0.48	7
	St. Paul, Minn.	72.9	91	52	39	6.5	36	NW	1.51	0.59	11
	Duluth, Minn.	64.8	87	49	38	8.9	34	NW	1.82	0.53	11
	Bismarck, N. Dak.	69.4	100	41	59	7.7	56	NW	0.45	0.22	4
	Average.	70.8	91	51	40	8.2	37	—	3.20	1.16	11
Southern Cities.	Washington, D. C.	76.6	94	54	40	5.6	36	NW	6.66	2.23	12
	Louisville, Ky.	78.6	95	59	36	4.9	22	N	2.09	0.92	9
	St. Louis, Mo.	78.8	93	63	30	7.1	31	W	4.54	1.26	12
	Savannah, Ga.	81.3	98	65	33	8.2	30	SW	4.97	1.94	10
	Kansas City, Mo.	76.2	93	59	34	5.9	38	NW	5.57	2.43	9
	Jacksonville, Fla.	81.2	96	67	29	7.3	42	W	6.12	1.40	13
	Chattanooga, Tenn.	78.6	98	61	37	5.4	27	S	2.27	0.67	13
	New Orleans, La.	82.6	93	69	24	6.1	27	SE	5.45	2.61	13
	Memphis, Tenn.	80.0	94	65	29	5.0	35	W	5.86	2.36	8
	Palestine, Tex.	81.3	97	63	34	5.2	28	NW	4.52	1.68	9
	Average.	79.5	95	62	33	6.1	32	—	4.74	1.75	11
Western Cities.	Helena, Mont.	67.6	98	43	55	7.7	55	SW	0.63	0.33	7
	Port Crescent, Wash.	57.2	89	39	50	5.7	18	W	0.08	0.06	2
	San Francisco, Cal.	55.9	73	48	25	15.3	41	W	0.00	0.00	0
	Salt Lake City, Utah.	76.2	97	51	46	5.8	32	N	0.42	0.27	6
	Santa Fe, N. Mex.	67.5	84	52	32	5.5	27	E	4.71	1.41	20
	Denver, Colo.	70.4	95	51	44	7.4	35	NW	1.92	0.45	14
	Yuma, Ariz.	—	—	—	—	—	—	—	—	—	—
	Average.	65.8	89	47	42	7.9	35	—	1.29	0.42	8

ROBERT STEPHENSON & CO. is the name of a new company which will acquire the business of the historic firm of Robert Stephenson & Co., engineers and shipbuilders, of Newcastle, England. The old firm was established in 1823, by George Stephenson, his son Robert, and Edward Pease, its original purpose being the construction of locomotives. This business has languished of late years, however, and shipbuilding and marine engineering have been added. The new company will apparently give greater attention to these latter branches of the business, as the works are to be greatly enlarged, overhead electric cranes will be erected at the shipbuilding slips, and a power plant will be established for operating the dock machinery, pumps, tools, etc., by electricity. A new dry-dock will also be built. The company has a capital of $2,500,000, but though the old name is retained there appears to be no Stephenson in the company, although the chairman of the Board of Directors is Sir Joseph Whitwell Pease. Representatives of large shipbuilding and engineering firms constitute the Board of Directors.

A MOTOR GUN-CARRIAGE, carrying a Colt automatic rapid-fire gun, is being built in Peoria, Ill. There are three wheels, seats for four men and provision for carrying at least 1,000 cartridges. The whole affair will weigh about 1,000 lbs. An ordinary 6-HP. petroleum motor is used. The apparatus is designed for city use against mobs.

THE NEW JERSEY ELECTRIC VEHICLE TRANSportation Co. on Aug. 7 increased its capital stock from $100,000 to $1,200,000. This is one of the branch concerns organized by the Whitney-Elkins syndicate, with James E. Hayes as President. The company expects soon to have motor-vehicles in operation in the larger cities and towns and at the seaside resorts in New Jersey; and will establish the New Jersey system as a model for the systems to be established in other states. The parent company says that it has already 4,800 vehicles manufactured.

MIRRORS OF GREAT DIAMETER can be manufactured at very much lower cost than under present methods by a process which is now being patented. A mirror of 10 ft. diameter, with an area of 85 sq. ft., has been made at Chicago, and has been used to melt stone and refractory metals, a reducing lens being used to concentrate the rays and intensify the heat. This device is claimed to possess advantages over the electrical furnace, and to be specially adapted for the production of the most expensive refractory metals, such as palladium, osmium, etc. It is being used to operate a heat engine, generating electricity, which is used to charge storage batteries. It can also be adapted to astronomical purposes, and for lighting dark rooms in buildings, etc., the mirror reflecting diffused light as well as the direct rays of the sun. The mirror is of glass, and its special feature is that the focus is adjustable, the mirror being made plane or concave at will, and the means of effecting this are being kept secret until the patents are secured. The inventor is a Swedish engineer, Mr. Knute C. Wideen, 267 Michigan Ave., Chicago.

THORITE, a new high explosive, represented by Dr. Hiram P. Tuttle, of Tacoma, is being tested at Sandy Hook. On Aug. 8 a 12-in. service shell was charged with 39 lbs. of thorite and fired from a seacoast rifle with 450 lbs. of brown powder. The shell was not fused, and went out to sea without exploding. It has already stood previous trials, and has always been fired with absolute safety to the gun. On Aug. 8, 20 shells, each carrying 2½ lbs. of thorite, were successfully fired from a 5-in. gun, though the record showed 40,000 lbs. per sq. in. chamber pressure, or 4,000 lbs. above the service standard. To demonstrate its destructive force thorite has been fired and exploded from the 7-in. Ames rifle—with 5 lbs. of thorite in the shell; the exploded shell flew into "a thousand pieces," and the test was highly satisfactory to the ordnance officers. At the same place the Isham diaphragm shell is being tested. This shell, invented by a Vermont engineer, is especially designed to carry any high explosive with safety. Two 12-in. Harveyized nickel-steel plates are being set up at Sandy Hook, and these are to be attacked by 12-in. Isham shells.

THE SEPTIC TANK OF THE CHAMPAIGN SEWERAGE SYSTEM.

By Arthur N. Talbot, M. Am. Soc. C. E.*

A septic tank may be said to be a large tank, covered so as to exclude light and air, wholly or substantially, through which the sewage flows in such a way that it has a very regular current and a velocity so slow that the matters in suspension in the sewage rise or fall, by reason of differences in specific gravity, and are retained in the tank, there to be decomposed, while the effluent flows out at the further end of the tank. Devices are used to cause the flow to be distributed over some considerable depth, to prevent surface currents, and to take the effluent from a depth free from suspended matter. Under the conditions of darkness, ill-ventilation and moderate heat, minute organisms of the class known as anaerobic bacteria develop in great numbers in the tank. This biological growth and activity produces a chemical decomposition of the retained organic matter of the sewage, a reduction of its compounds into parts, a large portion passing off in the form of gases, a part as inorganic matter with the effluent, and a part as silt-like sludge or ash which is deposited in the tank. A light floating mat covers the surface of the tank. Both this and the bottom sludge contain little organic matter. While this action is mainly upon the organic matter held in suspension in the sewage, some reduction in the dissolved organic matter is also effected. The chemical action may be termed a de-nitrifying process, as contrasted with nitrification in sand filtration. The process is continuous and self-regulating, no attendance, or labor, being required, except for the occasional removal of the sludge. The whole process results in the removal of nearly all of the putrescible organic matter in suspension, and a part of that in solution, producing a clear effluent which may be discharged into small streams without resulting nuisance, and which may be filtered at a far more rapid rate than can crude sewage. It seems also to be true that the compounds are broken down so that after leaving the tank a further purification takes place in the stream much faster than would otherwise be effected.

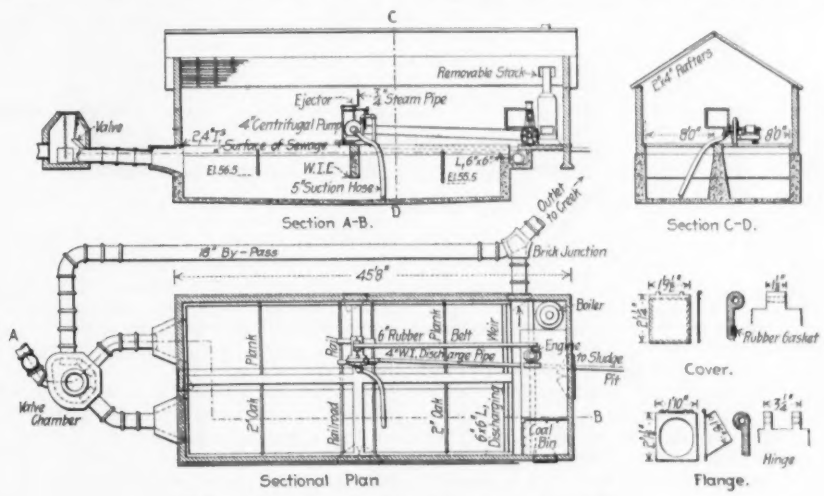


FIG. 1.—SEPTIC TANK AT CHAMPAIGN, ILL.
Prof. A. N. Talbot, M. Am. Soc. C. E., Engineer.

The following statements will make the conditions under which the Champaign septic tank is operating more readily understood. The population of Champaign is between 9,000 and 10,000. From 1895 to 1898, inclusive, 24 miles of sanitary sewers were constructed, and there are now over four hundred house connections on record. As these include hotels, boarding houses, restaurants, laundries, public buildings, and a part of the buildings of the University of Illinois, the condition is probably that of a town of 3,500, with all houses connected with the sewer. As the water company supplies water to both Champaign and Urbana, the water consumption cannot be used as a basis of estimate of sewage flow. However, dry weather gagings of the outlet sewer show a flow of 300,000 gallons per 24 hours. During much of the year considerable ground water reaches the sewer, and at times the flow is several times the above amount. The outlet sewer extends for two miles through the city of Urbana, and by reason of the distance and the flat grade over three hours is taken for the sewage from the main part of Champaign to reach the tank. It is believed that this long, slow journey is of value in preparing the sewage for the tank. The effluent is discharged into Salt Fork Creek, a small prairie stream, which has a dry weather flow of 2 to 6 cu. ft. per sec., and which in extremely dry seasons remains entirely dry for two months, but yet through much of the year has a flow of 10 to 20 cu. ft. per sec. For disposal grounds, the city of Champaign purchased twelve acres adjoining the east city limits of Urbana. The creek runs through this tract for about one-fourth mile, and the tract is available for the construction of artificial filter beds, there being a large sand bank within a half mile. At the time of the purchase, it was thought that further purification might at some time be necessary.

The septic tank, see Fig. 1, is about 37 ft. long, 16 ft. wide, and has a depth of 5 ft. of water, giving a capacity of 22,200 gallons. The tank is enclosed in a brick building having a shingle roof. Wooden doors and windows allow access and light for inspection and cleaning, but are ordinarily kept tightly closed. A longitudinal wall divides the tank into two compartments. While usually both are in operation, one may be kept in use while the other is being cleaned. The flow is divided at the valve chamber, and the enlarged mouth of the tank serves to distribute the flow over its full width, and over a considerable depth. Baffle boards or traps are placed across the tank, reaching down to a depth of 2 to 3 ft. below the surface. These serve to retain floating matter and to prevent surface currents. The middle one is of concrete, and serves also to stiffen the walls and support the pump. On the end wall, at the lower end of the tank, a 6 × 6-in. angle is placed with its upper edge level, forming a weir over which the effluent flows into the outlet channel. The weir takes the water uniformly from the width of the tank, and the depth of flow does not vary more than 1 in., thus keeping the tank in a nearly constant condition of flow. The effluent discharges into the creek near by. A 4-in. centrifugal pump, with flexible suction hose, run by a 5-HP. steam engine, is used to pump out the sludge. This is discharged through a 4-in. wrought-iron pipe into a shallow excavation near the bank of the creek, from which the liquid portion filters through the earth to the stream.

During the past year some study of the operation of the tank has been made. Analyses of the sewage and effluent, and of the gases and sludge, were made, and also an examination of the general conditions of operation. Great care was taken in collecting the samples of sewage and effluent* to make them not only representative of the flow at the time of collection, but also of that throughout the day. A galvanized-iron cylinder with its bottom removed was placed in the sewer at a manhole, and when the regular current was established through it the bottom was quickly replaced and the catch emptied into a large bucket, two or three such catches being taken together. This method allowed the collection of sewage for the full depth of flow in the sewer. After thoroughly mixing this sewage, an amount proportioned to the flow of the sewer at that time was measured and placed in the

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*In this and in other matters the writer is indebted to Mr. W. D. Gerber, University of Illinois, Class of 1899.

collection bottle. Similar samples were taken hourly throughout the day, except that the sewage from 2 to 6 a. m. (representing the flow back in town from 11 p. m. to 3 a. m.) was taken as represented by the flow at those hours. The resulting mixture is believed to give a fairly representative composite sample of the sewage of the day. Similar precautions were taken in collecting samples of the effluent, a composite sample through the whole day being taken in each case.

The chemical analyses were made by the chemist of the State Water Survey Department of the University of Illinois, under the direction of Dr. A. W. Palmer, Professor of Chemistry. Table I. gives the results of three composite samples. The flow of sewage, including infiltrated ground water in gallons per 24 hours, was about as follows: Nov. 22, 600,000 gallons; Feb. 6, 250,000 gallons; May 3, 400,000 gallons. The temperature of the sewage on Nov. 22 was 54° F.; Feb. 6, 47° F.; May 3, 50° F. The temperature of the external air on Feb. 6 was from 17° F. to — 2° F.

The reduction in the organic matter in suspension, as shown by the reduction in oxygen consumed, nitrogen as albuminoid ammonia and total organic nitrogen in Table I., averages 94%, a very high efficiency. The reduction in the organic matter in solution is considerable, the averages for the table above being 17%. The above are what may be termed cold weather results, and it is believed that warm weather results will be even better, since the bacterial activity is then greater. The effluent is seen to be nearly free from organic matter in suspension, and the amount in solution is not much greater than that in solution in the creek during the times of low water.

The large proportion of organic matter in suspension in the sewage is at least partly explained by the hardness of the city water and of the ground water, and the slight velocity in the sewers. Table II. gives a partial analysis of the hydrant water, a sample of infiltered ground water from a sewer known not to have any house connections, and the water of the creek above the sewer outlet at the time of moderately low water.

Gas is given off from the tank in considerable quantities, and when the sludge is stirred its evolution is quite noticeable. The large proportion of marsh gas makes the whole highly inflammable, and if the tanks are slightly disturbed, and a lighted match applied, a hot flame rises to a height of 3 ft. An analysis of the gas, made by Dr. A. W. Palmer, is as follows: Carbonic acid gas (CO_2), 10.7% of total volume; free nitrogen (N_2), 27.8; marsh gas (CH_4), 55.3; ethane (C_2H_6), 6.2; total, 100%. No trace of sulphuretted hydrogen is found.

The sludge at the bottom of the tank is a black, muddy-looking, silt-like deposit. The average of two analyses is as follows: Water, 60.9%; organic matter, 4.7%; inorganic matter, 34.4%. As compared with the sludge from chemical precipitation works, which has 92 to 98% of moisture, the sludge has little water. The organic matter is relatively small, and seems to be made up of quite stable compounds. The floating material at the top contains 92% moisture, 3% organic matter, and 5% inorganic matter.

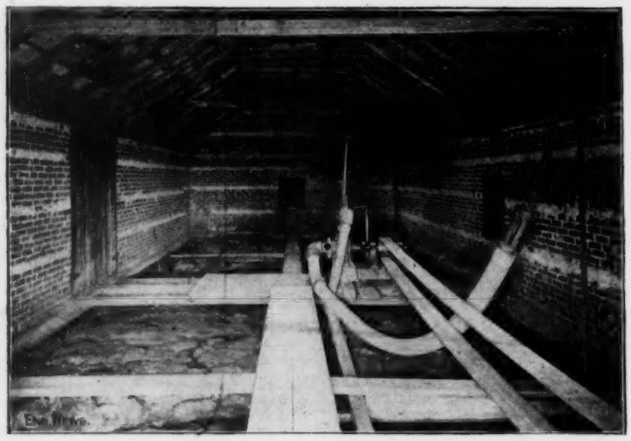

FIG. 2.—INTERIOR VIEW OF SEPTIC TANK AT CHAMPAIGN, ILL.

The value of the sludge as a fertilizer is small. An analysis made by Dr. C. G. Hopkins, Chemist of the Illinois Agricultural Experiment Station, gives the following results: Moisture, 59.7%; total nitrogen, 0.26%; water-soluble potash, 0.03%; total phosphoric oxid, 0.22%. The total value of one ton of sludge at the market prices of pure fertilizer would be 99 cts., and in the form of this mixture would be much less. It may be seen that while the sludge will serve excellently as filling or top soil, it cannot be sold as fertilizer.

The amount of this sludge is relatively small, but the accumulation requires removal occasionally. As near as may be estimated, the amount of sludge is about 3 cu. ft. of dry matter (moisture evaporated) per 1,000,000 gallons of sewage treated, exclusive of ground water flow in the sewers. This is considerably less than the sludge resulting from chemical precipitation, which amounts to 20 to 25 cu. ft. of dry matter per 1,000,000 gallons of sewage treated. The tanks have been pumped out three or four times a year. The sludge is mixed with sewage before pumping, and the tank has to be refilled with sewage, stirred, and pumped, and this operation repeated several times before the heavier matter is all taken out. The water seeps through the ground into the stream and the sludge is left in the bed of the sludge pit.

TABLE II.—Analyses of Hydrant, Ground and Creek Water at Champaign, Ill.
(Parts per 100,000.)

	Water,		
	Hydrant.	Ground.	Creek.
Total residue by evaporation	40.2	93.6	52.3
Fixed residue	37.7	84.0	46.9
Chlorine in chlorides	0.23	7.0	3.7
Oxygen consumed	0.43	0.17	0.7
Nitrogen as free ammonia	0.339	0.0024	0.132
Nitrogen as albuminoid ammonia	0.0125	0.0048	0.032
Nitrogen as nitrites	None.	0.0004	0.024
Nitrogen as nitrates	0.009	0.65	0.03
Total organic nitrogen	.....	....	0.072

TABLE I.—Analyses of Sewage and of Effluent from Septic Tank, Champaign, Ill.
(Parts per 100,000.)

	Nov. 22, 1898.			Feb. 6, 1899.			May 3, 1899.			Mean
	Sewage.	Effluent.	Efficiency.	Sewage.	Effluent.	Efficiency.	Sewage.	Effluent.	Efficiency.	Efficiency.
Oxygen consumed: In suspension	3.270	0.310	90.6%	3.950	0.150	96.0%	2.120	0.100	95.3%	94.0%
In solution	0.880	0.620	29.6%	0.950	0.710	25.3%	0.640	0.550	14.1%	23.0%
Nitrogen as albuminoid ammonia:										
In suspension	0.317	0.032	89.9%	0.550	0.016	97.1%	0.307	0.010	96.8%	94.6%
In solution	0.051	0.032	37.3%	0.042	0.038	9.5%	0.029	0.026	10.3%	19.0%
Total organic nitrogen:										
In suspension	0.712	0.072	89.9%	1.352	0.040	97.0%	0.704	0.032	95.5%	94.1%
In solution	0.083	0.083	0.0%	.....	.....	....	0.089	0.073	18.0%	9.0%
Nitrogen as free ammonia	0.304	0.288	...	0.640	0.600	....	0.640	0.560	....	....
" nitrites	0.140	0.125	...	0.200	0.180	....	0.067	0.067	....	....
" nitrates	0.425	0.425	...	0.800	0.875	....	0.400	0.500	....	....
Chlorine in chlorides	5.000	5.000	...	4.900	4.900	....	5.100	5.000	....	....

The operation of the septic tank has so far been very satisfactory. The effluent has been sufficiently pure to permit its discharge into the creek, and no objectionable results have been noted in the water below. No odor is noticeable around the tank. Within the effluent sewer a slight swamp-like odor is found. Inside the building the gases are very distinct, but the odors are not especially objectionable. When the contents are being pumped out, the smell is much stronger, but workmen suffer no great inconvenience. At such times, an odor like that of dirty water is noticeable around the pit into which the sludge is being pumped, but even on a warm day it cannot be detected 100 ft. away. The dry sludge contains relatively so large an amount of inorganic matter that its appearance and condition is not far different from prairie loam.

This septic tank has been in operation since 1897, although it was designed in 1895. It was an outgrowth of the writer's experience with the Urbana septic tank, which he constructed in 1894. The ideas for this came from a study of various settling tanks connected with sewage disposal works, the action of large cesspools, and the "automatic vault cleaner" of M. Mouras, described in Engineering News of April 15, 1882. The Urbana tank was covered with plank and earth and had a submerged outlet. Observation on its action proved that a material purification of the sewage was made, and the efficiency of the tank has been quite satisfactory. It may be noted that the development of the septic tank process in Urbana and Champaign was made at about the same time as that at Exeter, England, the two being entirely independent of each other, though along much the same lines.

It will be seen that the results in efficiency of purification in the Champaign septic tank are quite as good as those ordinarily obtained by the chemical precipitation process, and that the septic tank has a considerable advantage in that there is no expense for chemicals and attendance, and that on account of the decomposition and reduction of organic matter the sludge to be disposed of is comparatively small, and is largely inorganic matter, while the effluent is quite as pure. The method is especially applicable where the discharge of crude sewage into small streams not used as sources of water supply would create a nuisance. Where further purification is desired, the effluent from the tank may be filtered through beds of sand or coke, the removal of the suspended matter and the breaking down of compounds making it possible to filter several times as much of this effluent on a given surface as could be taken of crude sewage. Compared with most other processes, it is inexpensive both for cost of construction and operation. It is believed that the septic tank process, if properly developed, will prove to be an important means of sewage purification.

For existing conditions the design of the Champaign septic tank is satisfactory, but the writer believes he has made substantial improvements in several tanks which he has recently designed. The depth of water may advantageously be increased to 6 or even 7 ft. The width for ordinary lengths for small plants may not well be more than 12 ft., unless great care is used in making the inlet. The length may properly be several times that in this tank. The total capacity of the tank should probably equal the flow of the sewage for at least 4 hours, for while the Champaign tank has taken more sewage than warranted by this limitation, the increased facilities for the accumulation and reduction of sludge in a larger tank will give better results. It is quite doubtful, however, whether the provision for a capacity equal to 24 hours' flow is necessary or desirable.

It may be well to say that this system may be used without infringing on any patents. While a company claims to have a patent, the principles of darkness, non-ventilation, submerged outlet, and other features of the septic tank have been in use so long that they certainly are not patentable.*

*Other articles on or relating to the septic tank system of sewage treatment may be found in Engineering News as follows: Jan. 13, May 12, July 7, Aug. 4, 1898; Feb. 2, June 8 and July 13 (pp. 23 and 27), 1899.—Ed.